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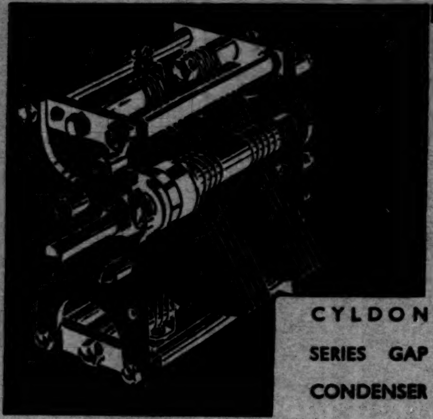

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*A Journal of Radio Research and Progress*

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VOL. VIII. No. 91. APRIL, 1931. MONTHLY.

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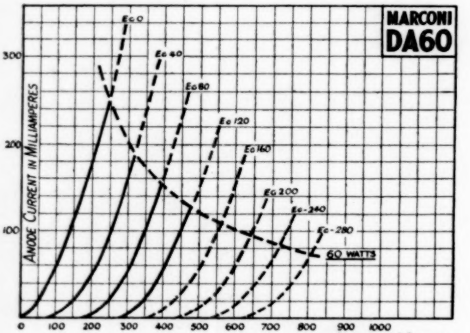

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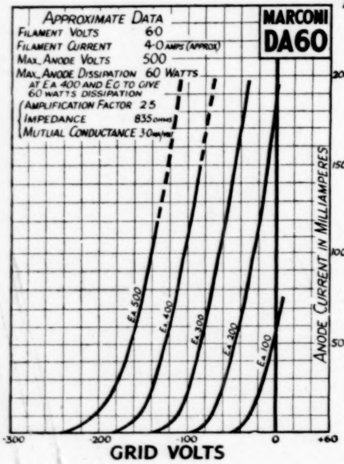

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EXPERIMENTAL WIRELESS & The WIRELESS ENGINEER

VOL. VIII. APRIL, 1931. No. 91.

# Editorial.

## A Super-rejector Circuit.

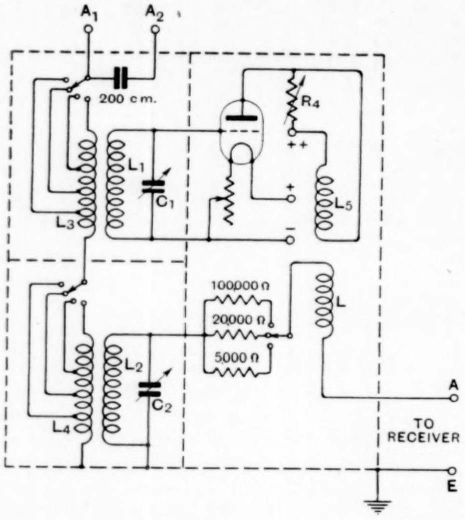
IN connection with the seventh German Radio Exhibition in August, the German Broadcasting Company offered a prize for an auxiliary apparatus which could be used in conjunction with an outdoor aerial and an ordinary good-quality receiver, in order to enable distant programmes to be received without interference from the neighbouring local or regional transmitter. It was also prescribed that the apparatus should minimise as far as possible the disturbance caused by electric tramways, X-ray apparatus, etc. In the two previous years somewhat similar offers had not met with success, but this year an apparatus was sent in which was not only awarded the prize, but which, after being tested by the Heinrich Hertz Institute for Radio Research, was considered of such merit that the Silver Medal of the Institute, which had not been awarded for three years, was awarded to the designer and constructor of the apparatus, an amateur, Theodor Eckert.

The problem which this apparatus is alleged to solve is not peculiar to Germany, and we feel sure that no apology need be made for bringing it to the attention of our readers.

A full description of the apparatus and of the tests made by the Institute is published in the December number of *Elektrische Nachrichten Technik*. Nothing is said concerning any effect the apparatus may have on the quality of the transmission, but, on the other hand, it is a relief to find that the laws of nature are not asked to go into abeyance while the inventor explains the action of his device.

Without the device an ordinary four-valve all-mains receiver (1 H.F. det. 2 L.F.) was useless for distant reception when tested at the Institute, because of the interference due to the main Berlin transmitter, the aerial of which is visible from the Institute. Even stations which differed in wavelength by 50 to 100 metres from that of the Berlin transmitter could not be received. When Eckert's device was connected between the aerial and the receiver, Kattowitz, which is only 18 kilocycles off the Berlin frequency, could be received entirely free from interference. One would like to know, however, if a simple tuned rejector circuit was tried, and, if so, with what success; not that we believe for a moment that it would have given such satisfactory results, but it would certainly have greatly improved matters. Now Eckert's device contains a valve, so that, strictly speaking, the results should be compared with those obtainable with a five-valve set. The valve is not used as an additional amplifying stage, but as an adjunct of the rejector circuit; the device might very well be described as a super-rejector.

It is on somewhat similar lines to the rejector devised by N. P. Hinton about ten years ago in which a valve with back-coupling was employed to reduce the damping of the rejector circuit.



The construction of the device can be seen from the diagram of connections. The aerial can be connected either to $A_1$ or to $A_2$, the latter connection introducing a series condenser of 200 cm. capacity. The aerial current passes to earth through two coils in series, contained in two screened compartments, two switches enabling one to vary the number of turns in circuit from 6 to 25 in each case, the coils being wound on tubes of 6 cm. diameter. The coil $L_3$ is coupled to a coil $L_1$ of 65 turns on the same tube, the coil $L_4$ being similarly coupled to a coil $L_2$, also of 65 turns. The circuit $L_1C_1$ constitutes a coupled rejector circuit; it is tuned exactly to the frequency of the disturbing station, and the voltage across $C_1$ is amplified by the valve, which produces in the coil $L_5$ of 20 turns a current of the disturbing frequency. This induces an electromotive force in the coil $L$, also of 20 turns, which can be adjusted by means of the variable shunt resistance $R_4$ of 600 ohms until it exactly wipes out the last traces of the disturbing station from the current passing to the receiver. In this respect the arrangement is a combination of a rejector and a compensating device.

The test report states that the tuning of the rejector is very critical, 0.5 metre departure from the exact wavelength being sufficient to bring in the disturbing station. This means that although the disturbing carrier wave may be cut out, the rejector will not cut out the higher side-bands, since 0.5 metre in say 300 metres is equivalent to a frequency change of 1,700 in $10^6$ cycles per second. Another trouble which will occur if the stations which are to be received have wavelengths too close to that of the local station is that the rejector will suppress one side-band of the desired station over a small range of audio-frequency. It is stated in the report that distant carriers could be tuned in free from interference within 9 kilocycles of the local frequency, and that Kattowitz, which differed by 18 kilocycles, could be received satisfactorily.

Turning our attention to the lower half of the diagram we see that the circuit $L_2C_2$, which is tuned to the desired distant station, feeds the receiver through a non-inductive resistance which is made adjustable. For lack of a suitable variable resistance of high quality, three resistances were used as shown. The object of this resistance is stated to be twofold, *viz.*, to provide a variable coupling between the tuned circuit $L_2C_2$ and the receiver, and to act as a buffer against shock disturbances such as those due to X-ray apparatus, etc. The inventor states that he has found it effective for this purpose, but nothing is said on this subject in the report of the Institute, and we must confess that we do not see how it fulfils this second object. Apart from this, however, the device is likely to prove of interest to those who find their efforts to obtain distant stations frustrated by the proximity of a powerful transmitter.

G. W. O. H.

# The Resistance Capacity Coupled Transformer.*

*By F. Aughtie, Ph.D., M.Sc., and W. F. Cope, B.A.* (*Cantab*).

THE recent developments of intervalve transformers rendered possible by the use of alloys of high initial permeability, realisable only in the absence of a polarising field, and the use with transformers of normal construction of valves taking higher anode currents than hitherto, give increasing importance to those circuits in which the steady anode current is not passed through the primary of the transformer.

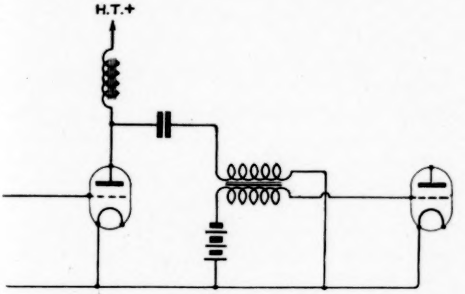


Fig. 1.

The use of a choke in the anode circuit, the transformer primary being fed through a suitable coupling condenser (see Fig. 1), has long been known and used. The analysis of this circuit has been given by Willans (*J.I.E.E.*, Vol. 64, p. 1079.)

The authors favour the circuit of Fig. 2 where the choke is replaced by a resistance; by this substitution, besides the removal of a potential source of distortion, in the shape of an additional iron core, the smaller self-capacity of a resistance as compared with a choke renders possible an improvement in the performance of the stage at high frequencies.

The D.C. voltage drop across the resistance is, in the majority of cases, an advantage rather than the reverse, since the H.T. supply for the final stage is usually much higher than that required on the anode of the preceding stages.

*Analysis of Circuit.*

The following symbols are used in the analysis :—

$e_{g1}$ = input voltage to grid of valve,
$e_{g2}$ = output voltage of stage,
$\mu$ = amplification factor of valve,
$R_a$ = slope resistance of valve,
$R$ = value of feed resistance,
$C$ = value of coupling condenser,
$L$ = inductance of transformer primary,
$r$ = resistance of transformer primary,
$\sigma$ = voltage ratio of transformer (taken as turns ratio).
$k$ = coupling efficiency.

At medium and high frequencies the reactance of the condenser is very low and hence the behaviour of the arrangement is substantially the same as a series circuit, with a correction for the presence of the shunting resistance.

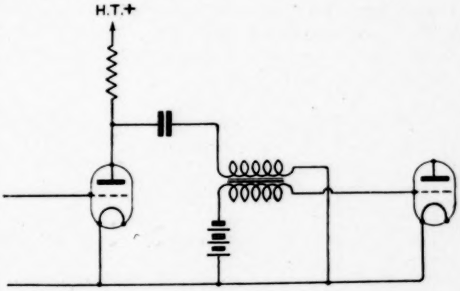


Fig. 2.

At low frequencies the secondary and mutual capacities, and leakage reactances, may be neglected, and the circuit redrawn as Fig. 3.

In usual vector notation, the impedance of the limb $C\ r\ L$ is :—

$$Z = r + j\left(\omega L - \frac{1}{\omega C}\right) \qquad \ldots \qquad \ldots \qquad (1)$$

---

* MS. first received by the Editor, July, 1929, and finally accepted February, 1930.

Hence the impedance into which the valve works is :—

$$\frac{R \times Z}{R+Z} \quad \cdots \quad \cdots \quad (2)$$

And the total impedance into which the voltage $\mu e_{g1}$ works is :—

$$R_a + \frac{R \times Z}{R+Z} \quad \cdots \quad (3)$$

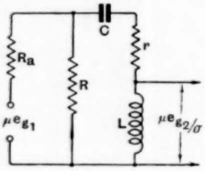


Fig. 3.

The current through the anode-filament path of the valve is thus :—

$$i_a = \frac{\mu e_{g1}}{R_a + \dfrac{R\,.\,Z}{R+Z}} \quad (4)$$

This divides into two parts, $i_1$ through $R$, and $i_2$ through $C\ r\ L$.

$$i_1 = \frac{Z}{R+Z}\,.\,i_a \quad \cdots \quad \cdots \quad (5)$$

$$i_2 = \frac{R}{R+Z}\,.\,i_a \quad \cdots \quad \cdots \quad (6)$$

The voltage across $L$ is therefore :—

$$j\,.\,\omega L i_2 = \frac{j\,.\,\omega LR}{R+Z}\,i_a = \frac{j\omega LR}{R+Z}\,.\,\frac{\mu e_{g1}}{R_a + \dfrac{RZ}{R+Z}}$$

which reduces to :—

$$\mu\,.\,e_{g1}\,.\,\frac{j\omega L}{R_a + Z\left(1 + \dfrac{R_a}{R}\right)} \quad \cdots \quad (7)$$

The voltage applied to the grid of the following valve is :—

$$e_{g2} = \mu\sigma e_{g1}\,.\,\frac{j\omega L}{R_a + Z\left(1 + \dfrac{R_a}{R}\right)} \quad \cdots \quad (8)$$

Hence :—

$$\frac{e_{g2}}{e_{g1}} = \mu\sigma\frac{j\omega L}{R_a + Z\left(1 + \dfrac{R_a}{R}\right)} \quad \cdots \quad (9)$$

and,

$$\left|\frac{e_{g2}}{e_{g1}}\right| = \mu\sigma\frac{\omega L}{\left\{A^2 + B^2\left(\omega L - \dfrac{1}{\omega L}\right)^2\right\}^{\frac{1}{2}}} \quad (10)$$

Where :—

$$A = R_a + r + \frac{R_a r}{R} = R_a + r\,.\,B$$

$$B = 1 + \frac{R_a}{R}$$

In this expression the product $\mu\sigma$ is independent of frequency for such frequencies as are being considered.

The remaining factor contains terms depending upon the frequency, and may conveniently be termed the efficiency of the coupling.

At zero frequency the efficiency is obviously zero, while at medium frequencies where $\frac{1}{\omega C}$ is small compared with $\omega L$, it has the value :—

$$\frac{\omega L}{(A^2 + B^2\omega^2L^2)^{\frac{1}{2}}} \doteqdot \frac{1}{B} \quad \text{since } \omega L >> A$$

$$= \frac{R}{R+R_a} \quad \cdots \quad \cdots \quad (11)$$

This is clearly less than unity and is equal to the coupling efficiency of a resistance stage having corresponding values of $R$ and $R_a$.

The form of the curve of coupling efficiency against frequency will depend upon the relative values of the constants, but if $C$ is less than a limiting value (see below), the curve will contain a hump corresponding to the series resonance of the circuit comprising the condenser, transformer primary, and the equivalent resistance of the feed resistance and slope resistance of the valve in parallel. The frequency at the summit of the hump, where the amplification is a maximum, is obtained by differentiating and equating to zero in the usual way.

Performing the differentiation,

$$k = \frac{\omega L}{\left\{A^2 + B^2\left(\omega L - \dfrac{1}{\omega C}\right)^2\right\}^{\frac{1}{2}}} \quad \cdots \quad (12)$$

$$\frac{dk}{d\omega} = L\,.\,\frac{\left\{A^2 - \dfrac{2B^2L}{C} + \dfrac{2B^2}{C^2}\cdot\dfrac{1}{\omega^2}\right\}}{\left\{A^2 + B^2\left(\omega L - \dfrac{1}{\omega C}\right)^2\right\}^{\frac{3}{2}}} \quad (13)$$

Equating to zero, we obtain

$$\omega^2 = \frac{2}{C\left(2L - \dfrac{A^2}{B^2}C\right)} \quad \cdots \quad \cdots \quad (14)$$

Examination of $\frac{d^2k}{d\omega^2}$ confirms the deduction, made from physical reasons, that this gives a maximum value to $k$, and not a minimum.

The form of (14) gives a real value of $\omega$ only when $\left(2L - \frac{A^2}{B^2}C\right)$ is positive. The physical interpretation of this is that the curve only has a hump when this condition is satisfied. At the limiting case, when $\left(2L - \frac{A^2}{B^2} \cdot C\right)$ is zero, *i.e.*, when

$$C = 2L\frac{B^2}{A^2} \quad \ldots \quad \ldots \quad \ldots (15)$$

the hump just vanishes.

Clearly values of $C$ less than that given by (15) must be used with caution since they result in the presence of a hump in the coupling efficiency-frequency curve; on the other hand, examination of a set of these curves for various values of $C$ shows that the use of a larger condenser is undesirable since it results in the curve rising up to the asymptotic value less quickly than when the constants satisfy (15).

Thus for a straight amplifier, *i.e.*, one in which no attempt is made to correct for deficiencies (or excesses) in the frequency response curve of other components, the best value for the coupling condenser is that given by (15). Further remarks on the choice of the value of $C$ will be made later.

The coupling efficiency—frequency characteristic will now be compared with that given by the standard series arrangement by examination of the cut-off frequency, defined as below.

Substituting from (15) into (12) and putting also :—

$$\omega = \omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{L\sqrt{2\frac{B^2}{A^2}}} = \frac{A}{\sqrt{2}.L.B} \quad (16)$$

we obtain

$$k_0 = \frac{LA}{A\sqrt{2}LB} = \frac{1}{\sqrt{2}B} \quad \ldots \quad \ldots (17)$$

The steady value of $k$ (*i.e.*, value at medium frequencies) is $\frac{1}{B}$ from (11). Hence we see that $k$ has a value 0.707 of its steady value when $\omega = \omega_0 = \frac{1}{\sqrt{L.C}}$. The corresponding value of the frequency is termed the cut-off frequency.

The efficiency of a series fed transformer stage can be obtained from (12) by putting $R = \infty \; C = \infty$.

$$k' = \frac{\omega L}{\{(R_a + r)^2 + \omega^2 L^2\}^{\frac{1}{2}}} \quad \ldots \quad \ldots (18)$$

The steady value of this is, of course, unity. To obtain the cut-off frequency $\omega_0'$ put $k' = \frac{1}{\sqrt{2}}$ obtaining :—

$$\omega_0' L = (R_a + r)$$

$$\omega_0' = \frac{R_a + r}{L} \quad \ldots \quad \ldots (19)$$

Comparison of this with (16) shows that :—

$$\frac{\omega'_0}{\omega_0} = \frac{\sqrt{2}(R_a + r)B}{R_a + r\,.\,B} = \sqrt{2}\left\{1 + \frac{R_a(B-1)}{R_a + r\,.\,B}\right\} (20)$$

This is very closely $\sqrt{2}B$ when $r << R_a$ and $B$ has a practicable value ($1 < B < 1.5$): thus by the sacrifice of some amplification at medium and high frequencies (in round numbers about 25 per cent.) the cut-off frequency has been reduced roughly an octave, quite apart from any gain in this direction consequent upon the increased transformer inductance following upon the removal of the polarising current from the transformer primary. Taking this latter into account, the reduction of the cut-off frequency obtainable in practice is commonly between one and two octaves.

Next compare the slope, at the cut-off frequency, of the coupling efficiency-frequency curves for the two circuits. For the circuit of Fig. 2

$$\frac{dk}{d\omega} = L\frac{\left\{A^2 - \frac{2B^2L}{C} + \frac{2B^2}{C^2} \cdot \frac{1}{\omega^2}\right\}}{\left\{A^2 + B^2\left(\omega L - \frac{1}{\omega C}\right)^2\right\}^{\frac{3}{2}}} \quad \ldots (13)$$

Substituting into the above

$$C = 2L\frac{B^2}{A^2} \text{ and } \omega = \frac{A}{\sqrt{2}\,.\,LB}$$

it reduces to :—

$$\left(\frac{dk}{d\omega}\right)_{\omega = \omega_0} = \frac{L}{A} = \frac{L}{R_a + r + \frac{R_a r}{R}} \quad \ldots (21)$$

For the ordinary series circuit

$$\frac{dk'}{d\omega} = L\frac{(R_a + r)^2}{\{(R_a + r)^2 + \omega^2 L^2\}^{\frac{3}{2}}}$$

$$= \frac{L}{(R_a + r)} \cdot \frac{1}{\left\{1 + \left(\frac{\omega L}{R_a + r}\right)^2\right\}^{\frac{3}{2}}} \quad \ldots (22)$$

Substituting

$$\omega = \omega_0' = \frac{R_a + r}{L}$$

we obtain

$$\left(\frac{dk'}{d\omega}\right)_{\omega = \omega_0'} = \frac{L}{R_a + r}\,\frac{1}{2\,.\,\sqrt{2}} \quad .. \ (23)$$

The rate of rise of $k$ at the cut-off frequency is seen to be greater for the resistance condenser fed arrangement than for the series arrangement. Hence it approaches the asymptotic value more rapidly, and the complete curve therefore more nearly realises the ideal of a horizontal straight line.

This theoretical deduction is confirmed by inspection of Fig. 7, in which the response curves (plotted from the formulæ) are given for series and for parallel resistance feed circuits.

Having established the theoretical foundation for the circuit, it is now necessary to show that the results are realisable in practice. In particular it is necessary to know what deviations from the theoretical performance result when the constants of the circuit vary slightly from their nominal values. It is difficult to demonstrate by mathematical methods that such deviations in $R_a$, $L$, and $C$ as are likely to occur individually are without serious effect upon the curve, and so curves have been prepared showing the effect of such departures from nominal values as are likely to occur.

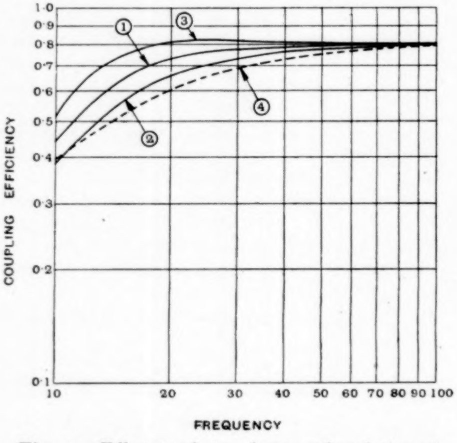


Fig. 4.—*Effect on shape of curve of variation of valve resistance. Curve* 1, *normal,* $R_a = 5{,}000$ *ohms. Curve* 2, 20% *increase,* $R_a = 6{,}000$ *ohms. Curve* 3, 20% *decrease,* $R_a = 4{,}000$ *ohms. Curve* 4, *transformer shunted by* 20,000 *ohms,* $R_a = 5{,}000$ *ohms,* $L = 45H$.

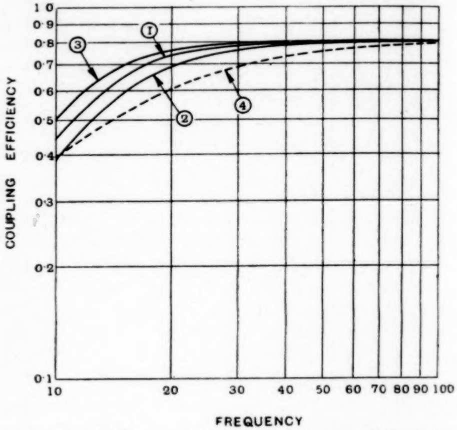


Fig. 5.—*Effect on shape of curve of variation of inductance. Curve* 1, *normal* 45*H. Curve* 2, 11% *decrease* 40*H. Curve* 3, 11% *increase* 50*H. Curve* 4, *transformer shunted by* 20,000 *ohms,* $R_a = 5{,}000$ *ohms,* $L = 45H$.

Fig. 4 shows the effect of a 20 per cent. variation of $R_a$ above and below the nominal value; Fig. 5 that of an 11 per cent. variation of $L$ above and below the nominal value; and Fig. 6 that of a 25 per cent. and a 50 per cent. reduction in the value of the capacity. These curves have been plotted for nominal values of the constants as follows:—

$R_a$ = 5,000 ohms.
$R$ = 20,000 ohms.
$L$ = 45 henrys.
$C$ = 4 microfarads.
$r$ = 1,000 ohms.

It will be noted that a slight gain, from the practical point of view, results from the use of a condenser somewhat smaller than that given by equation (15). For this reason the curve for a larger capacity has not been drawn. (It is interesting to note the analogous case of a damped indicating instrument where damping somewhat less than the critical value is most convenient in practice.)

It is clear that the modifications are of negligible magnitude, especially when regarded in connection with the frequency scale.

The fourth curve of these figures is the theoretical efficiency of a transformer stage when the primary is shunted by the resistance $R$. This curve is obtained from (12) by putting $C = \infty$, no account is therefore taken of any reduction of the primary inductance due to the presence of the polarising current.

The actual amplification of a transformer stage would be greater than the values given by this curve, but since only the form of the curve is being considered it is preferable to have the curves so that they have a common steady value.

Three additional curves are given in Fig. 7 to assist in comparing the coupling efficiency-frequency characteristics given by the circuit of Fig. 3 and the normal series arrangement. The first of these (curve 4) is the fourth curve of Figs. 4, 5, and 6, *i.e.*, the transformer with no polarising current, and the primary shunted by a resistance $R$.

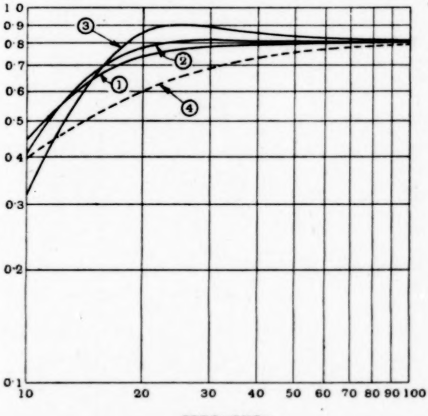


*Fig.* 6.—*Effect on shape of curve of variation of capacity. Curve* 1, *normal* 4 $\mu F$. *Curve* 2, 25% *decrease* 3 $\mu F$. *Curve* 3, 50% *decrease* 2 $\mu F$. *For* $R_a = 5{,}000$ *ohms*, $R = 20{,}000$ *ohms*, $L = 45H$. *Curve* 4, *transformer shunted by* 20,000 *ohms*, $R_a = 5{,}000$ *ohms*, $L = 45H$.

The second (curve 5) is that of the transformer with the primary unshunted and unpolarised, but with values of the amplification scaled down to 0.8 of their actual values so that the steady value is the same as that for the shunted transformer.

The third (curve 6) is the curve for the transformer as realised in practice when, due to the polarising current, the inductance has been reduced to 20 henrys.

It has been stated above that the voltage drop in the feed resistance is, in the majority of cases, an advantage rather than otherwise. It is sufficient to add here that the arrangement finds its best application in the penultimate stage of a power amplifier, the output stage of which is supplied with H.T. at 350 volts. The preceding valve will usually require about 150 volts on its anode, and there is thus ample voltage available for the drop in the resistance.

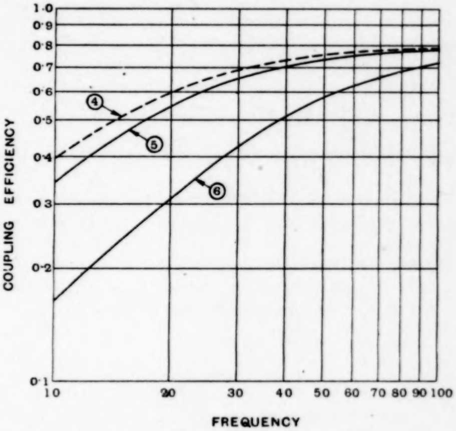


Fig. 7.—*Effect of shunting resistance and polarising current. Curve* 4, *shunted with* 20,000 *ohms. Curve* 5, *unshunted with no allowance for polarising current. Curve* 6, *unshunted allowing for polarising current. Note values for* 5 *and* 6 *have been multiplied by* 0.8 *to compare directly with Curve* 4.
$R_a = 5{,}000$ *ohms*, $L = 45H$ (*curves* 4 *and* 5)
$20H$ (*curve* 6).

At the cut-off frequency, *i.e.*, when $\omega = \frac{1}{\sqrt{LC}}$ the reactance of the arm $C\ r\ L$ is zero, and the external impedance into which the valve works is $\frac{R_a \cdot r}{R_a + r}$, a low value. The dynamic characteristic of the valve is thus not much different from the static one, hence, to avoid amplitude distortion, care must be taken that the swing at this frequency lies within the linear range of the static curve. This effect can usually be ignored since, except in a few cases, the cut-off frequency is well below any musical frequency.

*Feed Back.*

The audio-frequency current through the H.T. supply is :—

$$i_1 = \frac{Z}{R + Z} \cdot i_a \quad \ldots \quad \ldots \quad (5)$$

Substituting for $i_a$ and $Z$ we obtain :—

$$|i_1| = \mu e_{g1} \cdot \frac{(r^2 + X^2)^{\frac{1}{2}}}{R\{(Br + R_a)^2 + B^2X^2\}^{\frac{1}{2}}} \quad \ldots (24)$$

where $X$ has been written for $\left(\omega L - \frac{1}{\omega C}\right)$

Case 1. At medium and high frequencies $X$ is large and the expression reduces to

$$|i_1| = \frac{\mu e_{g1}}{R + R_a} \quad \ldots \quad \ldots \quad (25)$$

Case 2. At the cut-off frequency, $X = 0$

$$|i_1| = \frac{\mu e_{g1}}{R + R_a + R \cdot \frac{R_a}{r}} \quad \ldots \quad \ldots \quad (26)$$

This is obviously smaller than for case 1, and may become extremely small if $r << R_a$.

Case 3. At an intermediate frequency,

$$\begin{aligned} |i_1| &= \mu e_{g1} \frac{(X^2 + r^2)^{\frac{1}{2}}}{R\{(Br + R_a)^2 + B^2X^2\}^{\frac{1}{2}}} \\ &= \mu e_{g1} \frac{(X^2 + r^2)^{\frac{1}{2}}}{RB\left\{X^2 + r^2 + \frac{R_a^2}{B^2} + \frac{2R_a r}{B}\right\}^{\frac{1}{2}}} \end{aligned} \quad \ldots \quad \ldots \quad (27)$$

This is seen to be less than

$$\frac{\mu e_{g1}}{RB} = \frac{\mu e_{g1}}{R + R_a}$$

the value for Case 1. Thus the current through the H.T. supply is never greater than for Case 1, and decreases with the frequency down to the cut-off frequency. This is an advantage since the reactance of the condenser usually connected across the H.T. supply increases with decrease of frequency.

Below the cut-off frequency, the audio-frequency current through the H.T. supply increases again, but this is not likely to cause trouble due to feed back from succeeding stages since the amplification of the stage is extremely small below this frequency. Neither need it cause feed back trouble with preceding stages since they should be designed to give small amplification at these frequencies, for, clearly, there is no justification for amplifying in earlier stages what will not be passed by the stage under examination.

*Phase Shift.*

There will be a change of phase displacement between input and output voltages when $\omega$ passes through the value $\frac{1}{\sqrt{LC}}$, and while this corresponds to a frequency so low, in most practical cases, as to cause no trouble, the arrangement is not recommended for a number of stages in cascade. (Kirke, *E.W. & W.E.*, Vol. V, p. 447).

*Design.*

The most important consideration in design is the provision of sufficient output voltage for the following stage. The procedure advised is to divide the required swing by the ratio of the transformer which it is proposed to use, add 25 per cent. for the loss due to the shunting effect of the resistance, and then choose a valve capable of supplying this output, using the method given by Sowerby (*E.W. & W.E.*, Vol. V, p. 201). This fixes $R_a$ and $R$ : equation (16) then gives $\omega$ if $L$ is fixed, or, alternatively, gives $L$ for a given value of $\omega$. Substitution into equation (15) then gives the value of $C$.*

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* Curves giving values of $C$ and $\omega_0$ were included in "The Parallel Fed L.F. Amplifier," by Aughtie and Cope (*Wireless World*, Dec. 11th, 1929, pp. 644–7).

# The High-frequency Resistance of Coils.*

## Novel Methods of Measurement.

### *By A. L. Green, M.Sc.*

**SUMMARY.**—It is shown that there are methods of measuring the high-frequency resistance of coils which do not require the use of a thermo-junction and calibrated resistances. These methods depend on the condition for oscillation in a triode assembly, and the simplest of them uses the dynatron oscillator. Experimental results show that the condition-for-oscillation procedure can be made to compare favourably with resistance-variation as regards accuracy, and, in the case of the dynatron, there is the advantage that numbers of measurements over a range of wavelengths can be made in a short time.

## Introduction.

THE methods of measuring the high-frequency resistance of coils fall into three main classes: (*a*) by resistance-variation, (*b*) by distuning, and (*c*) by signal injection across a small resistance in series with the coil. All three require the use of a thermo-junction, since, even if the experiment takes the form of measuring the potential developed across the shunt capacity which tunes the coil, the valve voltmeter has to be calibrated initially from a known resistance carrying a measured current. Now, a thermo-junction is subject to two errors: one inherent in its calibration, and the other in the assumption made as to its heater resistance at high frequencies. Of these two, probably the latter tends to be the more serious as the frequency increases, since stray capacities, and, to a less extent, skin effect, tend to produce variations in the effective resistance of the heater which must eventually show as errors in the computation of the coil resistance. A further difficulty is that a part of the current in the coil flows back through distributed capacities and is not registered at all by the thermo-junction, while there is, too, some reason for thinking that it is not quite valid to make a correction for this effect simply by assuming a lumped capacity for the coil. Add the undoubted experimental difficulty of adjusting an oscillatory circuit exactly to resonance when a maximum reading of the thermo-junction galvanometer is the only indication of tune, and a case has been made out for an investigation of other methods of measuring coil resistances.

One is immediately reminded of the formula for the condition for oscillation in a triode assembly, in which the resistance of the grid coil occurs as a factor, and it appears worth while to make a few measurements to see just how accurate may be this possible method of measuring coil resistances.† One can see at once that there is something to be said for testing the coil in an assembly similar to that in which it will eventually function, instead of divorcing it entirely as is usually done, and even if, after a trial, the condition-for-oscillation method proves too clumsy, there is the satisfaction of verifying or disproving the formula used.

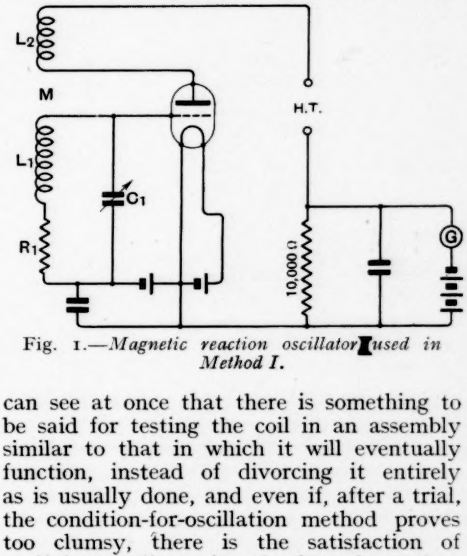

Fig. 1.—*Magnetic reaction oscillator used in Method I.*

## The Condition for Oscillation—Method I.

*Magnetic reaction.*

In Fig. 1 is the well-known circuit of a triode oscillator in which the anode coil $L_2$ is coupled magnetically to the grid coil $L_1$. It

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* MS. received by the Editor, May, 1930.

† I am indebted to Professor E. V. Appleton, F.R.S., for the original suggestion, made in 1925, that the conditions for oscillation of a thermionic valve generator might be applied in the determination of high-frequency resistance, and also for his subsequent help and advice.—A. L. G.

is easy to show by approximate methods that the effect of passing energy from the anode to the grid circuit by means of magnetic reaction is to reduce the effective resistance $R_1$ of the grid coil by the quantity

$$\triangle R_1 = \frac{\mu}{R_a} \cdot \frac{M}{C_1}$$

where $\mu$ and $R_a$ are the valve constants, amplification factor and slope resistance : $M$ is the mutual inductance (negative) between $L_1$ and $L_2$, and $C_1$ is a composite capacity including the tuning condenser, the lumped capacity of the coil and the input capacity of the valve. If, therefore, by increasing $M$, the valve is brought just to the point of oscillation, where the resistance of the grid coil is reduced to zero, we have

$$R_1 = \frac{\mu}{R_a} \cdot \frac{M}{C_1} \quad \cdots \quad \cdots \quad (1)$$

and substitution of the appropriate values of the quantities on the right-hand side should give a measure of $R_1$.

### *Experimental Details.*

Since negative grid bias was used to ensure that the valve was working on the straight part of its characteristic curve, it was not possible to make a test for oscillation by watching for a change in grid current, so observations were made in the anode circuit. Sufficient sensitivity was obtained by inserting into the anode circuit a 10,000-ohm resistance shunted by a large capacity and by a backed galvanometer.

The ratio of $\mu$ to $R_a$ was measured in the usual way by noting anode currents at specified grid potentials, the details of the last paragraph being in circuit.

The mutual inductance $M$ presented some difficulty owing to its small relative value, but the method finally employed was as follows: the grid coil was firmly screwed on to a graduated scale, and the anode coil made to slide along this. Measurements of the mutual inductance between the coils were made at intervals of half a centimetre, and from the results a graph was drawn from which intermediate values could be interpolated. The coils were separated temporarily from the circuit and connected in series together with a reversing switch, so that the total inductance of the assembly was $L_1 + L_2 \pm 2M$, according to the sense of the mutual induction. After adding a calibrated condenser in shunt, the resultant oscillatory circuit could be tested for resonant wavelength, and then calculations give $L_1 + L_2 + 2M$ and $L_1 + L_2 - 2M$, which by subtraction lead to $4M$. The oscillatory circuit was inserted into the anode circuit of a dynatron oscillator, and its signals picked up on a wavemeter. For each distance of separation between the coils, four readings are required on the wavemeter corresponding to two values of shunt capacity for each position of the reversing switch. It was found to be convenient to measure the inductance of each coil with the same arrangement, it only being necessary to put a short-circuiting plug in place of one of the coils while measurements were being made on the other.

Having found the inductance of the grid coil, it was decided to omit accurate measurements of its self-capacity and of stray capacities in the grid circuit of the triode oscillator, all of which are included in $C_1$, and to measure instead the wavelength at which oscillations just began. Accordingly, equation (1) was amended to

$$R_1 = \frac{\mu}{R_a} \cdot M \cdot \frac{4\pi^2 v^2}{\lambda_1^2} \cdot L_1 \quad \cdots \quad (2)$$

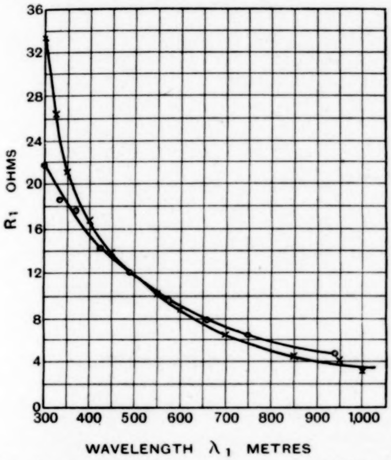
where $v$ is $3.10^{10}$ cms., and $\lambda_1$ is the wavelength of the grid circuit.

The procedure then was to set the coils at a separation for which the mutual inductance was known, and to vary the grid tuning capacity until an oscillation started, at the same time noting its wavelength. After taking a few positions of the coils, values of the high-frequency resistance of the grid coil could be computed over a range of wavelengths. In Graph 1 are shown the results for a coil of inductance 273 microhenrys, wound on the Burndept multi-layer system. This coil was also measured for high-frequency resistance by the "resistance-variation" method, and a comparison of the curves obtained by the two methods indicates that there is fair agreement in the middle of the wavelength range, but that the condition-for-oscillation method shows high at the higher wavelengths and low at the lower wavelengths. Such a result is difficult to explain on the basis of errors in measurement of the quantities $\mu$, $R_a$, and $M$, and one is forced to the conclusion that equation (2) may not accurately represent the true condition for oscillation. A little consideration shows that there are three factors unaccounted for in this simple formula :—

(*a*) Reaction through the grid-plate capacity, $C_0$ of the valve.

(*b*) The self-capacity $C_2$ and resistance $R_2$ of the anode coil, and

(*c*) Magnetic reaction from grid to anode circuits, in addition to the more obvious anode-to-grid transfer of energy.



Graph 1.—*Comparison of the condition-for-oscillation, Method I (circles), against resistance-variation (crosses).*

*Formula* $R_1 = \frac{\mu}{R_a} . \frac{M}{C_1}$.

After allowing for (*b*) and (*c*)*, we can amend equation (2) as follows :

$$\triangle R_1' . (1 - L_2C_2p_1^2) = \frac{\mu}{R_a} . \frac{M}{C_1} - \frac{M^2p_1^2}{R_a} . (1 + p_1C_2R_a) \quad .. \quad (3)$$

where $p_1$ is the angular frequency of the grid circuit, and is equal to $\frac{2\pi v}{\lambda_1}$.

It is found that $R_2$, the resistance of the anode coil, only occurs in association with $R_a$, in comparison with which it is negligible. If $p_2$ is the natural angular frequency of the anode coil, it is possible to use the more convenient form

$$\triangle R_1' . \left(\frac{1}{p_1^2} - \frac{1}{p_2^2}\right) = \frac{M}{R_a} . \{\mu L_1 - M(1 + p_1C_2R_a)\} \quad .. \quad (4)$$

The grid-plate capacity reaction introduces a further drop in apparent resistance of the grid coil, given approximately by †

$$\triangle R_1'' . (1 - L_2C_2p_1^2) = \frac{\mu - 1}{R_a} . \frac{L_2C_0}{C_1^2} \qquad (5)$$

or by

$$\triangle R_1'' . \left(\frac{1}{p_1^2} - \frac{1}{p_2^2}\right) = \frac{\mu - 1}{R_a} . p_1^2L_1^2L_2C_0 \quad (6)$$

The total reduction in grid-coil resistance will therefore be

$$\triangle R_1 = \triangle R_1' + \triangle R_1''$$

and when the valve is just oscillating—

$$R_1\left(\frac{1}{p_1^2} - \frac{1}{p_2^2}\right) = \frac{\mu}{R_a} . (ML_1 + p_1^2L_1^2L_2C_0) - \frac{1}{R_a}\{p_1^2L_1^2L_2C_0 + M^2 . (1 + p_1C_2R_a)\} \quad (7)$$

A comparison of equation (7) with the simple formula of (2) shows that this method of attempting to measure the high-frequency resistance of a coil is much too complicated to be satisfactory, but it is nevertheless of interest to correct the curve of Graph 1 in accordance with the new formula. By doing this we should get a check on the validity of (7), and at the same time find out the relative importance of some of its factors.

Going back for a moment to (4), which gives the reduction in grid circuit resistance of an oscillator using purely magnetic reaction, and on substituting the following experimental quantities

$\mu = 6$

$R_a = 65{,}000$ ohms.

$L_1 = 273$ $\mu$H.

$C_2 = 46$ $\mu\mu$F.

$M$ from 22$\mu$H. to 47.5 $\mu$H.

$p_1$ from 6.3 millions to 2 millions, ($\lambda_1$, 300 to 940 metres), it was found that $M\ (1 + p_1C_2R_a)$ was almost a constant quantity over the range of frequencies investigated, and its magnitude was about 20 per cent. of $\mu L_1$. This figure then is the error[*] introduced by factor (*c*)—that is, the energy fed by magnetic reaction from the grid to the anode circuit.

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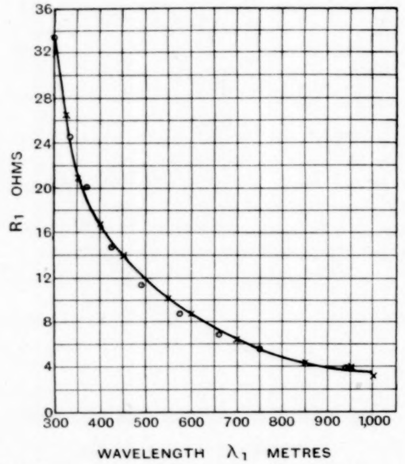
* *See* Appleton, *Proc. Phys. Soc.*, Feb., 1921. Joliffe and Rodman, *S.P. Bur. of Stand.*, No. 487, April, 1924. Morecroft, "Principles of Radio Communication," Chapter VI.

† *See* Miller, *Bur. of Stand.*, No. 351, Nov., 1919, etc.

Factor (*b*) is represented in equations (4) and (6) chiefly by $\left(\frac{1}{p_1^2} - \frac{1}{p_2^2}\right)$, and the effect of the natural frequency of the anode coil is to introduce an error which may be as high as 45 per cent. when the grid tuning capacity is at its lowest figure. The value of $p_2$ was 11.3 millions, and the highest value of $p_1$ used was 6.3 millions.

The error due to capacity feed-back, (6), varied from about 2 per cent. at the lowest grid circuit frequency, to 30 per cent. at the highest, when $L_2$ was 170 microhenrys and $C_0$, 4.5 $\mu\mu$F.



Graph 2.—*Resistance-variation (crosses) compared with condition-for-oscillation, Method I (circles), the formula being*

$$R_1\left(\frac{1}{p_1^2} - \frac{1}{p_2^2}\right) = \frac{\mu}{R_a}\,(ML_1 + p_1^2L_1^2L_2C_0)$$
$$- \frac{1}{R_a}\,(p_1^2L_1^2L_2C_0 + M^2 . \overline{1 + p_1C_2R_a})$$

Graph 2 is a comparison of the resistance-variation method of measuring coil resistances, and the results obtained by the complicated formula (7), in which full account has been taken of all the factors entering into the condition-for-oscillation method. Fairly good agreement has now been obtained at the expense of measuring all the quantities

$$C_0C_1C_2,\ L_1L_2p_1p_2\ M\mu \text{ and } R_a.$$

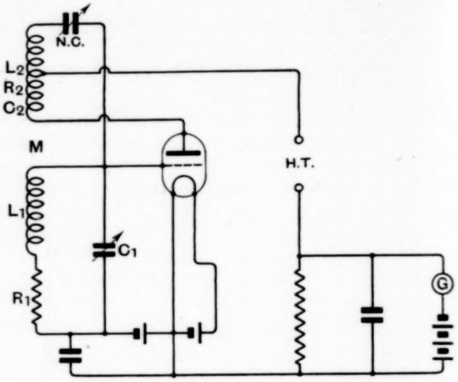


Fig. 2.—*The neutralised oscillator of Method II.*

Obviously such a method of finding coil resistances is open to serious experimental errors, but it is possible to eliminate the measurement of some of these quantities, for instance of $C_0$, if the capacity feed-back can be neutralised.

## Condition for Oscillation—Method II.

*The Neutralised Oscillator.*

Fig. 2 is the circuit of an oscillator in which the anode coil has been split and a neutralising condenser connected between the open end of the coil and the grid of the valve. Probably the easiest way to adjust the neutralising condenser to its proper value is to convert the circuit temporarily into a tuned plate tuned grid oscillator, by substituting a smaller coil in the grid circuit and tuning it to the frequency of the anode circuit. The coils can then be separated and mutually tuned, when the valve will oscillate until the grid-plate capacity is exactly neutralised. After this adjustment has been made the grid coil can be replaced.

A little consideration must now be given to the mutual inductance between anode and grid coils. First of all, it seems that one half of the anode coil is carrying the steady anode current, the oscillatory anode current and the capacity feed-back current, while the rest of the coil carries only the neutralising current. If the anode coil is an accurately centre-tapped solenoid, with a high ratio of diameter to length, the combined field due to the capacity feed-back current in one half of the coil, and the neutralising current in the other half, should be just zero, since these currents flow away from the centre of the coil and are adjusted to be equal in magnitude. We are left, therefore, with the fields due to steady and oscillatory anode currents, and, since these only flow in one half of the coil, our measurements of mutual inductance should be made between the grid coil and one half only of the anode coil. Otherwise the procedure is exactly the same as in Method I, and the experiment yields figures for the mutual inductance which can be substituted into the formula for the condition for oscillation. This, of course, can be adapted from either of equations (3) or (4), which are different forms of the condition for oscillation, where magnetic reaction only is used, so that the relevant equation for the neutralised oscillator is

---

[*] This error can obviously be minimised by reducing $R_a$ and $C_2$—that is, by using a valve with a high mutual conductance, and an anode coil with a low self-capacity.

$$\left(\frac{1}{p_1^2}-\frac{1}{p_2^2}\right).R_1=\frac{M}{R_a}\{\mu L_1-M(1+p_1C_2R_a)\} \quad \ldots \quad \ldots \quad (8)$$

Typical values are as follows :—

$\mu = 7$

$R_a = 26{,}000$ ohms.

$L_1 = 273\ \mu$H.

$p_2 = 11.1$ millions.*

$C_2 = 51\ \mu\mu$F.

$M$ from $7\ \mu$H. to $13.5\ \mu$H.

$p_1$ from 6.2 millions to 1.84 millions (306 to 1,030 metres $\lambda_1$).

In this assembly a valve has been used with a comparatively low anode slope resistance, the advantage being that the factor $-M\ (1+p_1C_2R_a)$ in equation (8) is now only about 3 per cent. of $\mu L_1$, and, being practically a constant quantity, it can be neglected in all but the accurate determinations of grid-coil resistance. The approximate condition for oscillation, in a neutralised oscillator where a valve is used with a high mutual conductance is, therefore

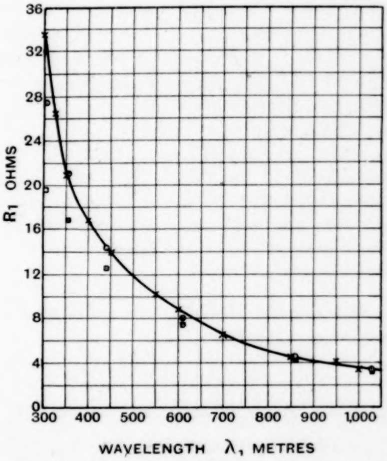
$$\left(\frac{1}{p_1^2}-\frac{1}{p_2^2}\right).R_1=\frac{\mu}{R_a}.ML_1 \quad \ldots \quad \ldots \quad (9)$$

Graph 3 is a comparison of the resistance-variation method of measuring coil resistances, and the neutralised oscillator condition (8), the coil under test being the same as used in Method I. As a matter of interest, points are also plotted using the formula

$$R_1=\frac{\mu}{R_a}.ML_1p_1^2=\frac{\mu}{R_a}.ML_1.\frac{4\pi^2v^2}{\lambda_1^2} \quad \ldots \quad (2)$$

which differs from (9) only in that the effect of the natural period of the anode coil has been neglected. This curve shows serious errors only at the higher frequencies, where the tuning of the grid circuit approximates to that of the anode circuit, so that it would appear possible to get fairly accurate determinations of coil resistance by using

(*a*) a neutralised oscillator,



Graph 3.—*Resistance-variation (crosses) compared with the neutralised oscillator, Method II. (Circles) by formula*

$$\left(\frac{1}{p_1^2}-\frac{1}{p_2^2}\right)R_1=\frac{M}{R_a}\,(\mu L_1-M\,.\,\overline{1+p_1C_2R_a)}$$

*(Squares) by formula*

$$R_1=\frac{\mu}{R_a}.ML_1p_1^2=\frac{\mu}{R_a}.\frac{M}{C_1}$$

---

* $p_2$ is measured by substituting a smaller grid coil, slightly deneutralising and converting thereby into a tuned plate tuned grid circuit, when the valve will oscillate at the fundamental frequency of the anode coil.

(*b*) a high-mutual conductance valve,

(*c*) as small an anode coil as possible, consistent with the necessary value of $M$ required for oscillation.

With these three conditions fulfilled, the condition-for-oscillation method becomes a little more tractable, since the simple formula of (2) can be used without serious error, and the experiment reduces in practice to determinations only of $M$ and $\lambda_1$ and the valve constants.

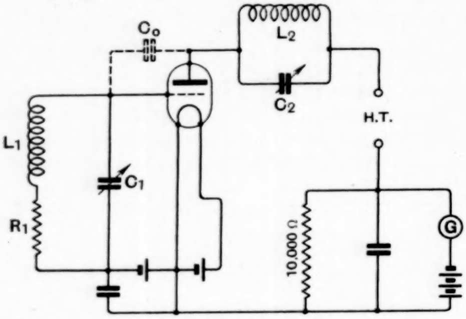


Fig. 3.—*Capacity feed-back oscillator, Method III.*

It may be noted, too, that the only "instruments" necessary for this method of measuring coil resistances are a wavemeter and a standard variable condenser, the latter being used in the determination of the mutual inductances.

### Condition for Oscillation—Method III.

*Capacity Reaction.*

The alternative to magnetic reaction and the measurement of mutual inductance is capacity reaction where the value of the grid-plate capacity of the valve must be known. The circuit of such an oscillator is in Fig. 3; both grid and anode coils are tuned by condensers, and zeroed for mutual inductance. The experiment consists in setting the grid circuit to the wavelength at which it is desired to measure the resistance of the grid coil, and in varying the tuning of the anode circuit until oscillations just set in. Generally there will be a wide band of anode tuning over which the valve will oscillate, but only one of the limits of this region is required. It is probably best to calibrate the anode circuit so that its resonant frequency can be found subsequently from the reading of the tuning condenser. The condition for oscillation of this capacity feed-back oscillator can be obtained from either of equations (5) and (6) and is

$$\left(\frac{1}{p_1^2} \sim \frac{1}{p_2^2}\right) . R_1 = \frac{\mu - 1}{R_a} . p_1^2 L_1^2 L_2 C_0 \qquad (10)$$

where $p_2$ is the angular frequency of the anode circuit when oscillations just begin, and $p_1$ is the angular frequency of the grid circuit oscillations. The grid-plate capacity $C_0$ was measured by comparison with a standard condenser, and the quantity determined includes the capacity of the valve-holder. Values of the quantities are:

$L_1 = 273\ \mu\text{H}.$

$L_2 = 1{,}150\ \mu\text{H}.$

$C_0 = 8.4\ \mu\mu\text{F}.$

$\mu = 18$

$R_a = 85{,}000$ ohms.

and the variables were in two cases

| | | | |
|---|---|---|---|
| $p_1$ | 4.7 | 2.1 | millions. |
| $p_2$ | 2.05 | 3.05 | millions. |
| $R_1$ | 16.4 | 4.3 | ohms. |
| $\lambda_1$ | 400 | 900 | metres. |

Corresponding values of the grid-coil resistance $R_1$ at wavelengths of 400 and 900 metres were, by the resistance variation method, 16.8 and 4.1 ohms. Owing to the difficulty of making an accurate determination of the grid-plate capacity* with the apparatus available, a more detailed investigation was not attempted, but the results obtained seemed to show that a fair accuracy can be expected with this method.

### Condition for Oscillation—Method IV.

*The Dynatron.*

Probably the most interesting oscillator, from the point of view of high-frequency resistance measurements, is the dynatron†, since here we can work with a single coil and a very simple condition for oscillation, namely:

$$R = \frac{L^2 p^2}{-R_a} \quad .. \quad .. \quad (11)$$

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* There is something to be said for increasing the grid-plate capacity artificially to a higher and more easily measurable quantity.

† *See* Gill and Morrell, *Phil. Mag.*, Feb., 1925. Hull, *P.I.R.E.*, Feb., 1918, and March, 1922.

where $R$ and $L$ are the high-frequency resistance and the inductance of the coil, $p$ is the angular frequency at which oscillations just begin, and $R_a$ is the slope of the anode current anode voltage characteristic, or, more popularly, the anode circuit negative resistance.

The circuit is shown in Fig. 4. Provision is made for varying and measuring the filament current by including in the filament circuit a rheostat and an ammeter, while a milliammeter measures anode current. The experiment proceeds as follows: With the anode coil short-circuited the anode voltage anode current characteristic curve is traced, and a note taken of the linear portion of the negative slope. Then the filament current is varied in steps, and the anode circuit negative resistance found in each case, by noting the change in anode current for a small variation in anode voltage, the reference point being the centre of the linear portion of the characteristic. We now have a calibration of anode circuit negative resistance against filament current, and it only remains to open the anode coil switch and vary the tuning condenser until a sudden change in anode current shows that oscillations have commenced. Their frequency can be measured with a wavemeter, and, providing the anode tuning condenser is calibrated, two such readings will give by calculation the inductance of the anode coil. Measurements of the coil resistance over a range of wavelengths are made possible by varying the filament current, when there will be an anode condenser setting, and a frequency at which oscillations commence, corresponding to each value of anode circuit negative resistance.

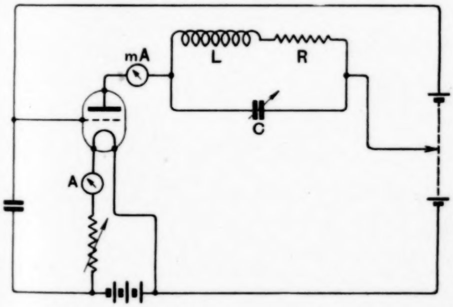
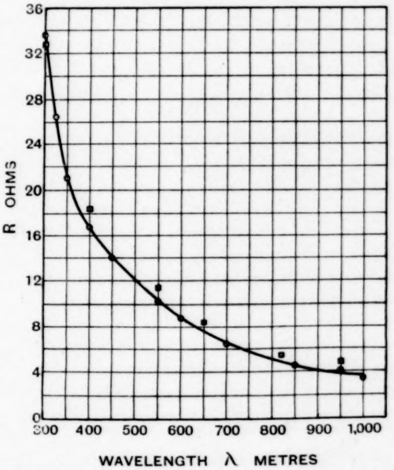


Fig. 4.—*The dynatron, Method IV.*

Experimental results for the coil of 273 μH. are in Graph 4, which compares the dynatron method with resistance variation. The agreement is not perfect by any means, but the dynatron method is nevertheless well worth consideration for measuring coil resistances by reason of its simplicity and quickness in operation. Unless one is willing to contest the accuracy of the resistance-variation method, it is difficult to explain the discrepancies of the dynatron results, but it is probably sufficient to say here that the dynatron is likely to be more useful at very high frequencies, where stray capacities and skin effect are bound to make work with a thermo-junction uncertain.



Graph 4.—*Resistance-variation (circles) compared with the dynatron (squares) by the formula* $R = L^2p^2/ - R_a$

It may be of interest to append here a few notes on a problem in high-frequency resistance the experimental solution of which is much simplified by using some such method as that outlined above.

## The Relation between High-frequency Resistance and Wavelength.

It is known* that the high-frequency

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* *See* Butterworth, *Phys. Rev.*, June, 1924, and Maullin, Radio-frequency Measurements.

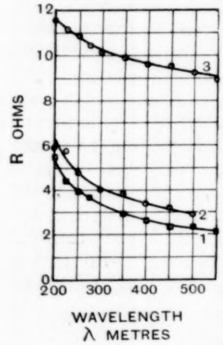
resistance of a coil follows the law

$$R = R_0 + \frac{a}{\sqrt{\lambda}} + \frac{b}{\lambda^2},$$

where $R_0$ is the resistance for direct currents, $a$ and $b$ are constants, and $\lambda$ is the wavelength at which $R$ is measured. Now, from the point of view of maintaining a constant amplitude of oscillation* in a magnetic reaction set when the tuning is varied with the condenser shunting the grid coil, it would be an advantage to increase the constant $b$ with respect to $a$. If we could design a coil whose resistance increased inversely as the square of the wavelength only, and use it in the neutralised oscillator, we can see from equation (2)

$$M = \frac{R_1 \lambda_1^2}{4\pi^2 v^2} \cdot \frac{R_a}{\mu} \quad \ldots \quad \ldots \quad (2)$$

that the mutual inductance would be a constant quantity whatever the oscillation wavelength. Put in another way, a receiving set incorporating a reacting detector could be kept on the verge of oscillation over the whole of its tuning range without any adjustment being made to the reaction control. Unfortunately, the theory of coil high-frequency resistance gives little help in designing such a coil, since the $b/\lambda^2$ term is only an experimental fact explainable on the lines of a leakage conductance, so that we must get some practical results first to point the way. A fairly obvious line of attack would be to make up a number of coils all of the same inductance, but wound with several diameters of wire on formers of varying sizes. The measurement of the coil resistances over a range of wavelengths would be tedious, but the work can be lightened considerably if the dynatron method is used.

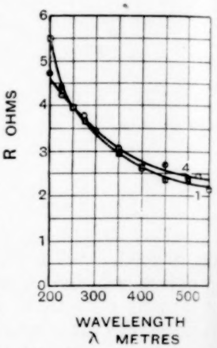


Graph 5.—*Three coils wound on 7 cm. diameter formers. Coil 1 with 18-gauge wire; Coil 2 with 30-gauge; Coil 3 with 40-gauge.*

The experiments were divided into two parts. First the coil former diameter was constant, and several coils were wound with wires of varying gauge. Secondly, the coils were wound with the same wire on formers of varying diameter. Results are shown in Graphs 5 and 6; all coils had an inductance of 64 $\mu$H., and their specifications are below. The experimental curves of high-frequency resistance against wavelength were analysed, and their characteristic equations found in each case, after the form

$$R = R_0 + A\sqrt{n} + Bn^2 \quad (12)$$

where $n$ is the frequency, it being more convenient to work with frequency than wavelength in this case.



Graph 6.—*Two coils wound with 18-gauge wire on different formers. Coil 4 on a former of 3.2 cms. diameter (circles). Coil 1 on a former of 7 cms. diameter (squares).*

| Coil | $R_0$ | $A \times 10^3$ | $B \times 10^{12}$ | Former diameter | Gauge of wire | $\frac{B}{A} \cdot 10^9$ |
|---|---|---|---|---|---|---|
| 1 | 0.7 | 1.24 | 1.45 | 7 cms. | 18 | 1.17 |
| 2 | 1.5 | 1.27 | 1.29 | 7 cms. | 30 | 1.01 |
| 3 | 7.2 | 2.35 | 0.61 | 7 cms. | 40 | 0.26 |
| 4 | 0.8 | 1.83 | 0.79 | 3.2 cms. | 18 | 0.43 |
| 1 | 0.7 | 1.24 | 1.45 | 7 cms. | 18 | 1.17 |

It appears from this table that—

(1) The ratio $B/A$ increases with the thickness of wire.

(2) The ratio $B/A$ increases with the diameter of the coil former.

(3) For a wavelength of 300 metres, which is approximately in the middle of the range investigated, $\sqrt{n}$ is $10^3$ and $n^2$ is $10^{12}$, so that the figures in the columns under $A \times 10^3$, and $B \times 10^{12}$ represent exactly in ohms the contributions of the $A$ and $B$ factors to the total high-frequency resistance of the coil at this wavelength. It can, therefore, be seen from the table that the effect of leakage-conductance, *i.e.*, $Bn^2$, is a

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* The argument which follows is valid only for very small amplitudes of oscillation, since other considerations obtain when the valve is being used as a source of power.

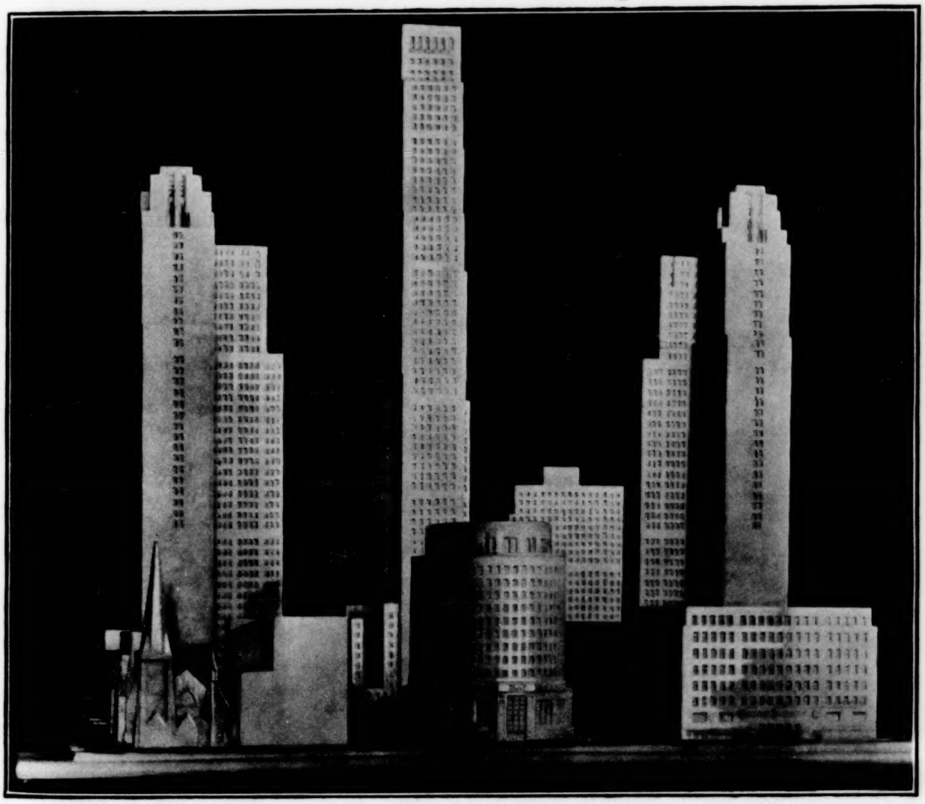
considerable fraction of the total resistance of the coil.

(4) The coil which most nearly approaches the law, $R = Kn^2$, is wound with thick wire on a large diameter of former. This, therefore, is the type of coil which should be used in an oscillator where a constant output is required over a range of wavelengths.

Much more experimental work would, of course, have to be done before one could settle the question of the leakage-conductance term, and the results given here are not meant to be in any way exhaustive or conclusive, but just as an illustration of the kind of problem in which one could find good use for unorthodox methods of measuring the high-frequency resistance of coils.

# "Radio City."

## America's New Broadcasting Centre.



*The illustration reproduced above shows a model of the proposed new buildings intended to provide a home of Broadcasting in the United States. The scheme has been planned by the Radio Corporation of America, Radio Keith Orpheum, and the National Broadcasting Company, and the cost has been estimated at 250 million dollars.*

*The central feature will be a 68-storey building which will house the executive offices of the various concerns and their associated companies, and the lower floors of the building will accommodate some thirty-six broadcasting studios. The area to be occupied by the group of buildings to comprise "Radio City" is roughly 1,150 feet by 1,500 feet.*

# A Saturated Diode as an Anode Resistance.*

### *By J. F. Herd, A.M.I.E.E.*

THE voltage amplification factor of a thermionic valve is ordinarily defined as

$$\frac{\text{change of } v_a \text{ to produce a given change in } i_a}{\text{change of } v_g \text{ to produce the same change in } i_a}$$

or

$$\mu = -\frac{\delta v_a}{\delta v_g} \; (i_a \text{ constant}) \quad .. \quad (1)$$

It is also well known that when a valve of voltage-factor $\mu$ and internal resistance $r$ is used as a resistance-coupled amplifier with a resistance $R$ in series with its anode circuit, the resultant stage-factor $\mu_s$ is given by

$$\mu_s = \frac{R}{R + r}\mu \quad .. \quad .. \quad (2)$$

In practice $\mu_s$ is always less than $\mu$, and can only be made to approach $\mu$ by having $R \gg r$, with a correspondingly great increase of high-tension battery, to keep the anode of the valve at the necessary potential.

MM. Jouaust and Decaux† have suggested the use of a saturated diode in place of the usual type of resistance as a means of obtaining something approaching very closely to the full voltage-factor of the valve, and have shown the application of the suggestion to a resistance-battery coupled amplifier, as shown in Fig. 1.

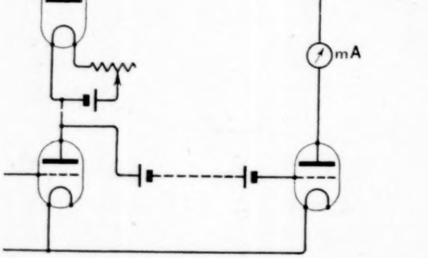


Fig. 1.

The present writer was led to examine the matter in connection with the use of such an amplifying system in the investigation of atmospherics, and this paper gives some measurements made with a few British valves of ordinary commercial supply.

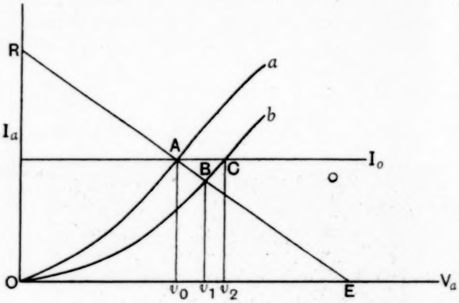


Fig. 2.

Jouaust and Decaux explain the operation of the system by the aid of the conventional graphical representation of resistance coupling given in Fig. 2. Curves *a* and *b* are the anode-current/anode-voltage characteristics for $v_g = 0$ and $v_g = -1$ respectively. The length *OE* is the voltage of the H.T. battery and the line *ER* is drawn so that $EO/OR = R$. The line *ER* cuts the curves at such points as *A* and *B*. The length $v_0$ to $v_1$ then represents the voltage release in the anode circuit for $-1$ volt change on the grid. If, however, the anode current is not altered by the change of grid voltage—as, for example, in the case of the horizontal line $I_0$—then the change of $-1$ volt on the grid causes a voltage release of $v_0$ to $v_2$, representing the full voltage-factor of the valve.

The horizontal condition $I_0$ cannot be achieved with an ohmic resistance in series with the anode of an amplifying valve, but if this resistance is replaced by a saturated diode a very fair approach to that condition prevails over quite a considerable region.

The experimental measurements described below show the extent to which the full voltage-factor of the valve may be achieved by the use of this method. As the arrangement was under examination primarily for the purpose of d.c. amplification, the tests described were all done at d.c., but in one case a set of check measurements was also made at frequencies from 500 cycles to 50 kc. per second.

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* MS. received by the Editor, March, 1930.

† *L'Onde Électrique*, July, 1929 ; *cf.* also Rudolph, *Archiv. für Elektrotechnik*, 28th June, 1930.

## Experimental Results.

The apparatus and method of measurement are shown in Fig. 3, where it is seen that either an ordinary type of anode-circuit (cartridge) resistance, or a diode could be introduced in series with the anode circuit. The actual voltage of the anode was measured by means of an electrostatic (Ayrton-Mather) voltmeter. Sets of readings of $v_a$ and $i_a$ were taken against $v_g$ under various conditions. The results are shown in Figs. 4, 5, and 6.

In the case of Fig. 4, the valve was one of 19.5 to 20$\mu$ and 16,500 ohms internal resistance—these values being measured and compared with the maker's figures of 17.5$\mu$ and 16,500 ohms respectively. Curve *A* shows variation of $v_a$ and curve *a* shows $i_a$ against $v_g$ with 50,000 ohms resistance in the anode circuit. *B* and *b* give corresponding quantities with 100,000 ohms. The $v_a$ curves show a change per grid volt of 12.5 and 14 respectively, values which are in close agreement with that calculated from equation (2). It may be mentioned that readings of $v_a$ were not prosecuted below 30 to 40 volts as the voltmeter scale became so congested that readings could not be accurately made, while the range already readable with accuracy was quite sufficient to give the desired comparisons.

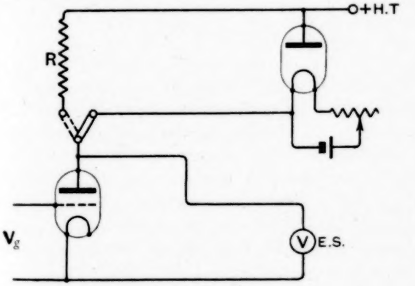

Fig. 3.

The diode was then substituted for the resistance, and its filament voltage adjusted to a value where early saturation was known to exist.

Curves for $v_a$ and $i_a$ with the diode are shown at *C* and *c* respectively in Fig. 4 with the diode filament adjusted to saturate at the value of about 1.2 to 1.3 mA. as shown.

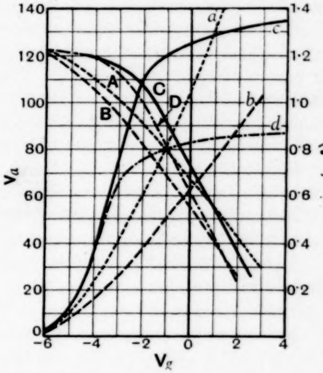

Fig. 4.—*Value of* $\mu$19.5, *r* 16,500 *ohms.* $A = v_a$, $a = i_a$ *for* $R = 50{,}000$ *ohms;* $B = v_a$, $b = i_a$ *for* $R$ 100,000 *ohms;* $C = v_a$, $c = i_a$ *for sat. diode;* $D = v_a$, $d = i_a$ *for sat. diode (reduced saturation).*

The curve *C* shows a change (of anode voltage) per grid volt of about 19 to 20, that is, practically the full voltage-factor of the valve. Readjustment of the diode filament to saturate at about 0.8 to 0.85 mA. yielded the curves *D* and *d*, where *D* is seen to have effectively the same slope as *C*. It is noticeable that the curves for the diode, as compared with those for the resistances, show first a more gradual change of anode voltage bending fairly abruptly into the region of rapid and (as nearly as could be measured) linear change at the point where the saturation of the diode begins to take charge of the conditions.

In the case of Fig. 5 the valve had measured constants of $\mu$40 and 80,000 ohms internal resistance. Curves *A* and *B* are of $v_a$ with 50,000 and 100,000 ohms respectively, *a* and *b* being the corresponding curves of $i_a$. The curves *A* and *B* show $\delta v_a/\delta v_g$ of about 16 and 21 respectively, which are again in good agreement with calculated values. The curve *C* is variation of $v_a$ with the diode, and shows $\delta v_a/\delta v_g$ of about 37 to 38. This again shows a very marked increase of stage-factor over ordinary resistance values, with much more conservative values of high-tension battery than would be possible with the alternative method of very high anode-circuit resistances.

Some measurements were also made with a screened-grid valve. It is known that with valves of this type a large voltage-factor, in conjunction with a correspondingly increased internal resistance, can be obtained by reduction of the screen voltage. With the anode at 120 V. and the screen at 70 V., an amplification factor of about 100 was measured in the ordinary way. Reduction of the screen voltage to 20 V. sent this value up to about 500, with an internal resistance of 1 megohm, all the values quoted being, of course, those for the valve alone.

With a diode used, as before, in lieu of an anode-circuit resistance, the variation of $v_a$ against $v_g$ was measured as shown in Fig. 6. The central and approximately linear region of this curve shows a change of $v_a$ of the order of 45–46 V. for 0.1 V. change on the grid, equal to a stage-factor of about 450–460. The region of straight is, of course, over a very limited grid-swing, which is a natural concomitant of such large single-stage yield.

By way of check, the use of the arrangement with alternating input voltages was also measured in one case, *i.e.*, that of the valve whose d.c. behaviour is shown in Fig. 4.

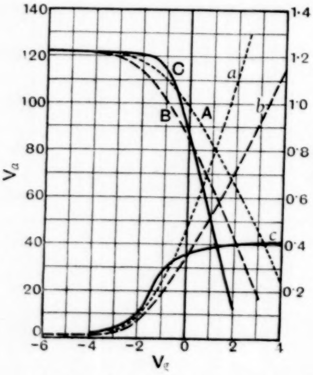

Fig. 5.—*Value of* $\mu$*40, r* 80,000 *ohms.* $A = v_a$, $a = i_a$ *for R* 50,000 *ohms* ; $B = v_a$, $b = i_a$ *for R* 100,000 *ohms* ; $C = v_a$, $c = i_a$ *for saturated diode.*

For this measurement the electrostatic voltmeter was replaced by a thermionic (Moullin) instrument, so as to measure only the alternating component of $v_a$. The input was applied through an attenuation network*, the thermionic voltmeter being first applied to the input of the network, and then transferred to the anode, while attenuation was introduced into the network to reduce the voltmeter reading to the same value as before. The attenuation so inserted thus measured the amplification of the stage. Using, as an input source, an audio-frequency oscillator of 500 to over 4,000 cycles per second frequency, the attenuation necessary was everywhere between 25 and 26 T.U., corresponding to voltage amplifications of about 19, *i.e.*, approximately that of the valve. Continuing with inputs of radio frequency from an ordinary oscillating wavemeter, the amplifications were as follows :—

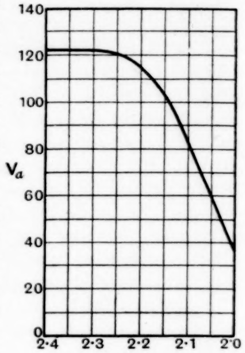

Fig. 6.—*Saturated diode with screened-grid valve,* $\mu = 500$, $r = 1$ *megohm.*

| Frequency. | Voltage Amplification. |
|---|---|
| 15 k.c.p.s. | 19 |
| 20 | 18.5 |
| 30 | 16.2 |
| 50 | 13.5 |

The thermionic voltmeter, when joined to measure the output, gave a very fair approximation to the usual conditions of load as in an ordinary resistance-capacity-coupled cascade, so that the measurements afford an indication of the behaviour of the diode arrangement when used as an anode-circuit resistance under ordinary working conditions.

## Application to a Two-stage Cascade.

Since the above notes were written the scheme of Fig. 3 has been applied to the design of a resistance-battery-coupled amplifier of one or two stages, for work on the wave-form of atmospherics.†

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* *Cf. Experimental Wireless and Wireless Engineer*, January, 1929.

† *Cf.* Appleton, Watson Watt and Herd, *Proc. Royal Soc.*, London, A., Vol. III, 1926, p. 615.

The alternative arrangement of anode circuit shown in Fig. 3 has simply been continued to a two-stage cascade, while output switching permits the use of one or two stages to the indicating device, which is a cathode-ray oscillograph. Measurement of the overall amplification of one and two stages, with ohmic resistance or saturated diode in either or both anode circuits, gives results which are in complete agreement with those already shown, and which approach very closely to the attainable maximum of the amplification factor of the valve or valves.

The disadvantage of the isolated battery required for the diode filament is not at all serious in practice. With low-consumption valves, the battery in each case is a single accumulator cell, of small ampere-hour capacity, which is easily accommodated inside the apparatus, so that insulation difficulties are no greater than in the ordinary wiring of an amplifier where high anode voltages are already in use.

The writer is indebted to the Department of Scientific and Industrial Research for permission to publish these results, which have been obtained in connection with the work of the Radio Research Board. He is also indebted to Mr. W. G. Hayman for assistance in the experiments and for the a.c. measurements referred to above.

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# The Practical Correction of a Wireless Direction-finder for Deviations due to the Metalwork of a Ship.

### (Paper by C. E. Horton, M.A., read before the Wireless Section, I.E.E., on 4th March, 1931).

## Abstract.

AFTER a brief introductory review of the errors that may occur in direction finding, the author turns to those due to the immediate surroundings of the direction-finder as in a ship. Considering the plane wave shown in Fig. 1*, the author discusses the local fields due to the different currents set up and shows that the whole of the forces acting at $Z$ can be reduced to

(1) A component $H \sin \omega t$ due directly to the wave and directed at an angle $\alpha + 90°$ to the fore-and-aft line.

(2) A component $R \sin \omega t$ at an angle $\epsilon$, and

(3) A component $Q \cos \omega t$ at an angle $\psi$.

$R \sin \omega t$ may be further combined with $H \sin \omega t$ to give a single resultant $P \sin \omega t$ and we are left finally with two fields, one $P \sin \omega t$ in phase with the wave acting at an angle $\phi$ and the other $Q \cos \omega t$ in quadrature acting at an angle $\psi$.

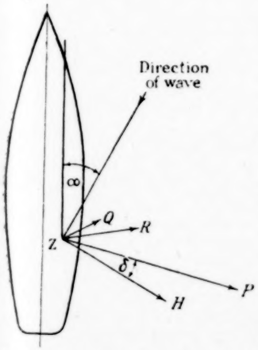

Fig. 1.—*General case of a direction-finder at a position Z.*

In general these two forces will be in different directions and a rotating field is produced. A coil situated at $Z$ has an e.m.f. induced in it no matter how it is directed. In other words, there is no zero and we have the familiar phenomenon of a blurred minimum. But if the coil is placed perpendicular to $P \sin \omega t$ only the quadrature component $Q \cos \omega t$ induces an e.m.f. in it.

Suppose now that a source of e.m.f., also in quadrature with the force of the wave, is available and that its amplitude can be made equal to $-Q$; then it is clearly possible to produce a perfect zero by injecting it suitably into the circuit of the frame coil.

### Quadrantal Correctors.

For a wave incident at an angle $\alpha$ to the centre line, $R$ consists of two terms $b \sin \alpha$ directed fore-and-aft and $f \cos \alpha$ athwartships, $b$ being the component due to the beam loop and $f$ that due to the fore-and-aft loop, and therefore $b/f$ is small. The total force $P$ acts at an angle

$$\arc \tan \left\{ -\frac{H+f}{H+b} \cot \alpha \right\}$$

with the centre line, giving an apparent direction of arrival of the wave of

$$\arc \tan \left\{ \frac{H+b}{H+f} \tan \alpha \right\}$$

which is nearer to the fore-and-aft line than $\alpha$.

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* The author's original figure-numbers are adhered to throughout this abstract.

The deviation $\delta$ is zero for $a = 0°, 90°, 180°$ and $270°$ and changes sign every 90 degrees, and is therefore termed quadrantal.

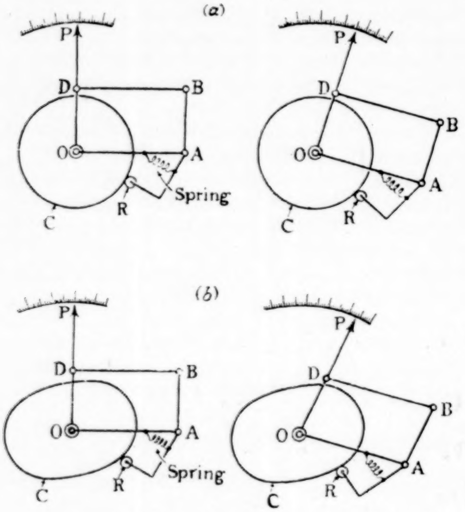

Fig. 4.—*Diagram illustrating cam corrector. (a) Roller bearing on circular section of cam. (b) Roller bearing on elliptical section of cam and giving a correction.*

Methods of correcting quadrantal error are then discussed. In the case of Bellini-Tosi or Fixed Aerial Systems, the corrections are :—

(*a*) One loop is set up fore-and-aft and the other loop athwartships. The relative dimensions of the two loops are adjusted by trial and error until a signal at 45° gives equal currents in the two aerials. To secure this result the fore-and-aft loop has to be made smaller than the beam loop. An area ratio varying between 0.7 and 0.9 is common in battleships. Adjustment at 1,100 metres is found to hold good for all longer waves, but for shorter waves may not be correct.

(*b*) With aerials of convenient dimensions equality of currents for a signal at 45° may be achieved by adding impedance to the better aerial, addition of inductance to each side of the loop being the usual practice. This method is shown to be less efficient for the shorter waves.

(*c*) Alternatively the reduction can be effected by shunting the field coil of the fore-and-aft aerial by an inductance. This method remains more true for shorter waves than the method (*b*).

With rotating coil systems the corrections are :

(*a*) A fixed loop surrounding the coil is set up in the fore-and-aft direction. With appropriate coupling the flux through the coil can be adjusted to have the value appropriate to the undisturbed field. This method is chiefly of theoretical interest and is not easy to adjust for different wavelengths.

(*b*) The difference between the true bearing and the bearing as given by the direction-finder is found in the first instance by trial. With the ship at a distance of a few wavelengths from a transmitter, direct comparison is made between the wireless bearings and the true visual bearing for different angles of incidence relative to the fore-and-aft line. A special scale can then be engraved to give correct bearings directly. This is not convenient when the scale of the instrument is connected with the ship's gyro-compass. The method therefore adopted is to operate on the pointer of the instrument so that it is displaced through an angle equal to the deviation. This can be done by a cam corrector operating on the principle shown in Fig. 4. When once the deviation has been ascertained by trial it is only necessary to make a suitably-shaped cam to obtain correct bearings directly from the scale. By constructing a solid cam it is possible to provide a range of values for the maximum quadrantal error. The cam of Fig. 4 is, in fact, a solid one of $\frac{7}{8}$in. depth and the particular cross-section of the cam on which the roller *R* works can be adjusted by a screw in the centre carrying graduations 0 to 15, the latter position giving a maximum correction of 15°.

Cam correctors can equally be applied to the pointer of a goniometer used with fixed aerials and specially shaped cams can be applied in cases of irregular deviation where electrical correction is not effective.

### Semicircular Correctors.

It is pointed out that although a ship is usually symmetrical about its centre line, it is never exactly symmetrical about a line drawn athwartships. Thus in Fig. 6 it is usually found that when a transmitter is exactly ahead or astern no signal is received by *PS*, but that when a transmitter is exactly on the beam some signal is still received by *FA*. A station on the beam, therefore, gives no real zero, although zero may be perfect for a signal ahead or astern. The e.m.f. in *FA* due to a transmitter on the beam is found in many instances to be in quadrature with the e.m.f. in *PS*, due to re-radiation from the ship and its aerials, and can be balanced out by a subsidiary source of e.m.f. in the right phase.

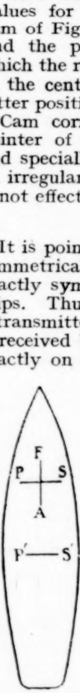

Fig. 6.

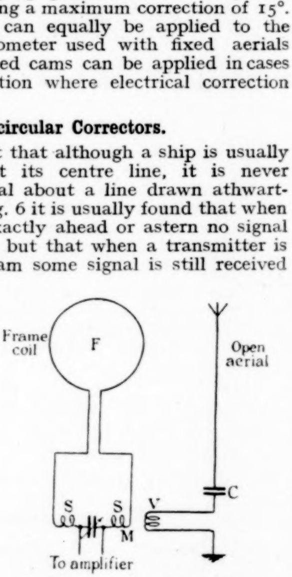

Fig. 7.—*Circuit for open aerial corrector.*

Several methods of applying this correction are discussed. One is shown in Fig. 7. Correct phase to 1° can be obtained by using a fixed condenser $C$ and ensuring that the aerial circuit is far from resonance. The correct coupling to obtain perfect zero varies for different directions. The adjustment is simple in practice, the movement of the coil and the variation of the coupling resembling the double-adjustment balance which is familiar in many a.c. bridges. With a goniometer a simple solution is to join the vertical aerial through an additional winding of the goniometer which is parallel to the field coil of the fore-and-aft loop.

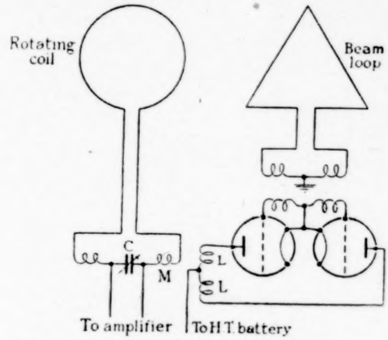

Fig. 10.—*Alternative circuit for beam loop corrector.*

Instead of using an open aerial it is possible to use a closed loop $P'S'$ as in Fig. 6. It is best to set up the loop athwartships, as shown, without appreciable coupling to the direction-finder aerial itself. To maintain correct phase it is desirable to use the valve circuit of Fig. 10.

If the impedance of $L$ is small compared with the impedance of the valve the current in the anode circuit is in quadrature with the voltage applied to the grid. To secure an accuracy of phase of 1° in this way demands an impedance for $L$ not more than about 1 per cent. of the impedance of the valve. When this is done, however, the correct phase relation between the coil e.m.f. and the subsidiary e.m.f. is maintained, even if the tuning condenser $C$ is not exactly in resonance.

### Ambiguity of Bearing.

The author then proceeds to discuss ambiguity and a new method of sense-finding arising out of these applications. The usual sense-finder employs a cardioid diagram, which necessitates a separate sense pointer and a sense-finding operation, since the cardioid is not generally suitable for accurate bearings. The author's system blurs the reciprocal zero, but leaves the true zero as sharp as before and in the original position. The device is shown in Fig. 11, in which $F_1$ is the main rotating coil and $F_2$ an auxiliary coil at right angles to $F_1$, and rotating with it. $V$ is an open aerial not coupled directly with $F_1$ or $F_2$. The coil $F_1$ alone gives two zeros 180° apart. When $V$ is added both zeros are blurred, but by the addition of $F_2$ one of these blurred zeros can be converted into a perfect zero, while the other becomes still more blurred. The system amounts to the addition of a cardioid to a figure-of-eight with the following conditions :—(1) The e.m.f. of the cardioid is in quadrature with the e.m.f. of the figure-of-eight. (2) The zero of the cardioid coincides in direction with one zero of the figure-of-eight. The actual amplitude of the cardioid is theoretically immaterial, provided the phasing is correct. The essential advantage of the system is that the sense is completely determined without prejudice to the accuracy of the bearing when the amplitude of the cardioid is only a small fraction of that of the figure-of-eight.

The paper next discusses the effect of the ship on the correcting aerials, since the field acting on this aerial cannot in general be in the same phase as the undisturbed field of the wave. From this discussion it is concluded that in general terms the problem of making a direction-finder which will give true bearings directly by scale readings can be resolved theoretically into getting two e.m.f.s, $E_1$, $E_2$, one of which ($E_1$) is in phase with the wave, and the other ($E_2$) in quadrature, and injecting $E_1$, $E_2$ into the circuit so as to counteract exactly the distortion of the wave due to the ship. $E_2$ eliminates blurring and $E_1$ corrects the deviation. Generally $E_1$ has four zeros in the 360° and $E_2$ two zeros. Under favourable circumstances there is symmetry in the disposition of these zeros and automatic correctors can be provided by simple means.

In the most general case, however, $E_1$ and $E_2$ do not follow precisely any simple law and it is necessary to find by trial exactly how they vary for different values of $\alpha$. To make the correction automatic it is then necessary to couple the rotating coil mechanically with two variable mutual inductances whose law of variation is adjusted by means of specially constructed cams to give the correct values of $E_1$, $E_2$ for any position of the coil. At present it is the practice to have only one cam and to adjust $E_2$ separately by hand. It should be noted that $E_2$ need not be exactly adjusted for a perfect zero in order to get the correct bearing. A slight blurring may be unimportant. But

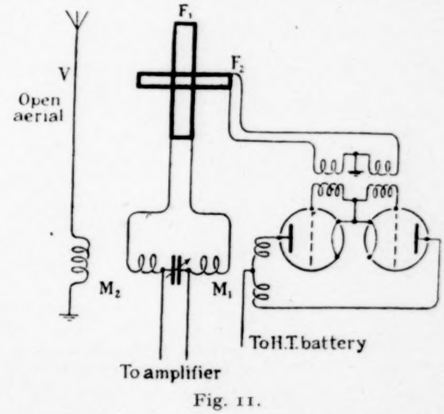

Fig. 11.

where time permits of the perfect zero being obtained the precision of a single reading can be very high—better than 0.5° with continuous waves. Under such circumstances the greater the amplification the more sharply defined the zero becomes.

### Best Position for a Direction-finder in a Ship.

It is not generally possible to choose the site for a direction-finder merely from electrical considerations, but experience gained in many ships has shown what is to be avoided and what can be achieved. The obvious position for a direction-finder is as high above the hull of the ship as possible. Apart from any difficulties in transferring the received voltages from the aerials to the office experience confirms this. Several positions on a ship are illustrated and discussed. It is a common experience that the best direction-finders are those in ships where it has been possible to fit them on the centre line approximately amidships with good symmetry both fore-and-aft and athwartships. A position immediately to one side of a single funnel is much inferior to a position between two vertical funnels.

A point of interest in the employment of correctors is their behaviour during periods of "night effect." Under these conditions the distortion produced by the ship is different from that produced on a wave travelling horizontally. The normal relations of amplitude and phase between the e.m.f. induced in the direction-finder and that in the vertical aerial are destroyed, so that when it is found necessary to employ unusual values of coupling to get a zero "night effect" is at once to be suspected.

### Discussion.

Mr. G. Shearing, who opened the discussion, said that there was probably no more complex application of wireless than naval direction-finding. In each of the methods described by the author there was only one tuning adjustment, so that even if circuits were not correctly tuned they could not affect phase or give wrong bearing. Blurring of the minimum was the worst that could occur. The system shown in Fig. 11 represented a true radio compass, and was applicable also to directional transmitters such as the rotating beacon. Vector diagrams of the e.m.f.s involved showed that the system gave as good minima as in the figure-of-eight diagram. There was evidence that $Q$ was greatest at wavelengths approximately equal to the length of the ship.

Mr. Smith said there was no reference to the wavelength range over which the correctors could be used. As regards "night effect" he referred to developments in the Adcock type of aerial, although the application to marine work represented additional difficulty. Had the author any information as to comparison against shore-type aerials on this scheme? In mercantile marine work there was as yet no demand for "night-error-free" direction-finding, but there might be advantages for naval work. What was the author's experience as to the lowest wavelength on which good bearings could be obtained, using transmission-lines to the goniometer? In mercantile marine work, conditions usually favoured the use of small loops and the Bellini-Tosi gave more choice of position than the rotating coil. The author's unambiguous scheme seemed complicated for long-wave ranges. The same operating advantages could be obtained by two search-coils on a Bellini-Tosi goniometer, one giving the bearing and the other for sense.

Mr. R. H. Barfield sought for information as to the adjustments of coupling, also as to the necessity for subsequent adjustment.

Dr. R. L. Smith-Rose desired information as to the degree of accuracy aimed at. One curve showed maximum errors of 3°. Was higher accuracy necessary? He also queried constancy of adjustment as in gales, etc., and as to the use of direction-finders on submarines.

Commander Warden dealt with several applications showing the importance of direction-finding in naval operations, strategic and navigational.

Mr. C. E. Horton, in replying to some of the points raised in the discussion, said that the systems worked on 300 to 5,000 metres. Experiments on shorter waves were still going on. Adcock aerials had been tried on shipboard. On medium waves, separation of $1/10\lambda$ was required, and the experiments so far had not been successful.

On the motion of the Chairman, Mr. C. E. Rickard, O.B.E., the author was cordially thanked for his paper.

# Correspondence.

*Letters of interest to experimenters are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.*

### The Design of Tuned Circuits to Fulfil Predetermined Conditions.

*To the Editor, E.W. & W.E.*

SIR,—I was rather mystified by Mr. Sowerby's article in *E.W. & W.E.* for January.

In June, 1929, I published an article dealing with the application of radio frequency transformers to screen-grid valves, and that article arose out of discussions with Mr. Sowerby in regard to these transformers.

One of the conclusions arrived at in the article was that, even with the best screen-grid valve, there was a definite magnification at which instability set in and that this magnification was not enormous. The formula for the onset of instability may be written

$$A^2 = 2g/\omega C_{pg},\text{*}$$

where $A$ is the stage magnification, $g$ is the mutual conductance of the valve, $C_{pg}$ is the grid-plate capacity and $\omega$ is the tuning pulsatance. With an extremely good screen-grid valve, *viz.*: $g = 800$ micromhos, $C_{pg} = 0.006$ $\mu\mu$F., this formula gives $A = 206$ at a tuning frequency of 1,000 kc.

At lower frequencies greater stage magnifications could be used without producing instability, but we should have to work below 250 kc. before the critical $A$ exceeded 400.

Now the puzzling thing is that in Mr. Sowerby's article a stage magnification of 400 is suggested, and his table is pushed to frequencies of 1,000 kc. True, he does not say that his system could be realised at these frequencies, but the reason he gives for this is that the coil losses, etc., would be such as to prevent the realisation of the proposed stage magnification, whereas the fact is that instability would set in long before the loss limitation was reached.

S. BUTTERWORTH.

Claygate, Surrey.

*To the Editor, E.W. & W.E.*

SIR,—Mr. Butterworth is quite right in saying that I have completely neglected the question of stability. He has, however, missed the fundamental point that the stage-gain is one of the starting-points of the calculation I suggested. The user of the equations is naturally expected, in choosing his stage-gain, to limit himself to a gain compatible with stability by applying the equation that Mr. Butterworth quotes, and which I had supposed to be well-known to anyone likely to perform design-calculations of this type.

The particular figure of stage-gain chosen for the numerical example was, as stated in the text, taken from some calculations for the intermediate stages of a superheterodyne receiver, and in that connection is an eminently reasonable figure (on paper, at any rate) even up to frequencies of 200 kc., which is the highest "intermediate" frequency given in my table. The extra figure for 1,000 kc. was added only for the sake of extending the figures into a realm of more familiar values, and to give extra point to the last paragraph of the article.

A. L. M. SOWERBY.

London, W.2.

[The above correspondence which has passed between Mr. Butterworth and Mr. Sowerby is published for general information.—ED.]

### Definition of Selectivity.

*To the Editor E.W. & W.E.*

SIR,—I have read with great interest and even greater admiration the letter from Mr. Pierre David on the definition of selectivity, published in your issue dated March 1931. It is a very masterly and judicial summing up of the situation, and with the principal conclusions I am in entire agreement.

My own endeavour to cover all the cases with a single formula was inspired by that desire for generalisation which is the main motive of the scientific method, but even before reading Mr. David's letter I had found myself forced to the conclusion that there is in fact no single formula which satisfies those essential requirements which Mr. David has specified so clearly.

I would like to suggest, however, that although the generalised procedure I originally proposed cannot be considered as universally applicable it nevertheless retains a certain and not unimportant sphere of usefulness, namely, all those cases where the various solutions of the resonance condition $\delta Z/\delta\omega = 0$ are so far removed from each other in frequency that the resonance peaks are distinct and separate. This would, of course, cover all the cases where there is only one solution for $\delta Z/\delta\omega = 0$, *i.e.*, all cases involving a single tuned circuit only, associated in any manner with other non-resonant elements. Mr. David suggests that even in such cases the calculations involved are complicated, but my own experience is that the complication can usually be avoided by judicious and legitimate approximation. I have, in fact, found the procedure to be very useful in relation to certain types of valve circuit involving only a single tuned system.

Coupled circuits and filter systems in general are typical of cases in which the solutions of $\delta Z/\delta\omega = 0$ are so close to each other in frequency that the component resonances of the system combine with each other and merge into a single peak. For such cases the procedure, though valid as regards each individual resonance, is no longer useful in relation to the whole, and there seems to be no general practicable specification for such cases other than the full description implied in Mr. David's proposals.

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* This formula is deduced from my Eqn. (12) after putting $G = 1$ and making a few transformations. I have also used $g$ for mutual conductance instead of $\sigma_{pg}$, as the latter symbol seems to have puzzled some readers.

It is to be hoped that these proposals will receive the attention that this increasingly important subject deserves.

F. M. COLEBROOK.

### An Alternative Equivalent Circuit for the Thermionic Valve.

*To the Editor, E.W. & W.E.*

SIR,—In your issue for September, 1930, Mr. Bligh has shown that the valve may be treated as a constant current generator shunted by a resistance equal to the anode resistance of the valve. He states in a footnote that a similar treatment of the valve circuit was published by Mayer in *Teleg. un Fernsprech Tech.*, November, 1926.

This method of treatment, however, is much older. It is referred to in a paper by myself published in August, 1920. (The Maintenance of a Vibrating System by Means of a Triode Valve, *Proc. Phys. Soc.*, London, Vol. 32, 1920, pp. 345-360. See para. 18 of this paper.)

I would not like to claim originality for the method, but I believe I was using it for the solution of valve problems early in 1919.

S. BUTTERWORTH.

Surrey.

### Ultra-short Wave Communication.

*To the Editor, E.W. & W.E.*

SIR,—I should like to offer some belated comments on Mr. C. C. Whitehead's paper on "Practical Experiments in Ultra-short Wave Communication" which appeared in *E.W. & W.E.*, Vol. 7, p. 542 and p. 612 (last October and November issues).

In Appendix (B) (4), p. 619, the effect of electron lag is discussed and the statement is made that "the amplitude of the oscillatory (A.C.) component of the anode current (and therefore the oscillatory energy produced) will be reduced by the amount :—

transit time/half time-period."

This result does not follow from the preceding paragraphs in the paper and, while the magnitude of the ratio might reasonably be taken as an indication of the frequency at which electron lag becomes important, I can see no logical justification for the statement quoted even as an approximation. The analysis of the effect of electron inertia in systems where both time and space variations are involved, leads to considerable complexities even in cases much simpler than that of the self-oscillating triode, and Mr. Whitehead's suggestion that these effects are "not difficult to estimate" is a little optimistic.

Assuming the general correctness of the statement quoted, if the load impedance remains approximately the same, the oscillating *power* would be reduced by the *square* of the time ratio (when the current is reduced by the first power of the ratio).

In the numerical estimation of the effect of electron lag there appears to be an arithmetical error in the evaluation of the expression for transit-time which comes to $3.8 \times 10^{-6}$ seconds for the figures quoted in the example instead of $3.2 \times 10^{-9}$. Putting this value in the expression for power lost due to electron lag we get 827 per cent. (of the output in the absence of lag) instead of 69.6 per cent. ! The reason for the absurd result is that the ratio $e/m$ has been expressed in electromagnetic units instead of electrostatic units which are appropriate to the problem. Perhaps a derivation of the expression for transit time more general than that given by Mr. Whitehead will make the matter clear.

The problem is that of an electron $(e, m)$ travelling from rest at one electrode to another distant $S_1$ units under the influence of a static p.d. $V_1$ between the electrodes, the field between the electrodes being uniform.

For the equation of motion we equate the instantaneous potential and kinetic energies of the electron :

$$V \,.\, e = \tfrac{1}{2} m \,.\, u^2$$

where $V$ and $u$ are the instantaneous potential and velocity respectively. (*Since $V \,.\, e$ is the potential energy, $V$ must be expressed in electrostatic units of potential and $e$ in electrostatic units of charge.*)

$$\therefore \quad u^2 = 2V \,.\, \frac{e}{m}$$

$$= 2\,V_1 \,.\, \frac{s}{s_1} \,.\, \frac{e}{m} \text{ for linear field.}$$

$$\text{Now} \quad t = \int \frac{1}{u}\, ds.$$

$$\therefore \quad t_1 = \frac{1}{\sqrt{2\,\frac{v_1}{s_1} \,.\, \frac{e}{m}}} \,.\, \int_0^{s_1} \frac{1}{\sqrt{s}}\, ds.$$

$$= s_1 \sqrt{\frac{2}{v_1 \,.\, \frac{e}{m}}} \text{ seconds.}$$

where $s_1$ is expressed in cm., $V_1$ in e.s.u. and $e/m$ in e.s.u./gm.

This expression is identical with that used by Mr. Whitehead for the transit time.

Taking $e/m = 0.542 \times 10^{18}$ e.s.u./gm, we find $t_1 = 1.19 \times 10^{-9}$ secs. for the example in the paper which gives a value for

(transit time/half time-period) of 26 per cent.

Squaring this we get about 7 per cent., a much more probable figure for the reduction of output than that obtained above. However, in view of the sweeping assumptions made—linear static field, zero space charge, zero initial velocities, not to mention the relation between the time ratio and oscillatory current reduction—I do not think this result justifies any more detailed statement than that electron inertia probably does reduce the output by a small amount in the case considered.

In the discussion of the various causes of R.F. loss in the transmitter (Appendix B. (3)) the losses in the valve itself appear to have been omitted except that some allowance has been made for the resistance of the leads. In addition to this, eddy current and dielectric loss will be considerable at frequencies of the order of $10^8$ and will probably account for quite a large fraction of the power converted by the valve.

The account of the effect of screening the bulb of the valve (Appendix B (1)) is very interesting and the necessity for further investigation is indicated. However, from the result that the effect is only important with large voltages and outputs it seems more likely to be due to the presence of ionised gas than to the effects of electron inertia. Another factor which may be of importance is the fact, pointed out by Langmuir,* that secondary emission can occur from a glass surface. If the glass is bombarded by high-velocity electrons more than one electron can leave it for each electron arriving, the surface then becoming positively charged instead of negatively as it would be in the absence of secondary emission.

Such secondary emission effects are usually of importance only at voltages of the order of tens of thousands, but Langmuir has shown† that they may occur with voltages of a few hundred. Secondary emission commences at voltages of the order of 20–100 and exceeds the primary bombardment of voltages of the order of 400 or more. There is at least a possibility of some electrons with velocities corresponding to this order of voltage escaping from the electrode system of a D.E.T.1 S.W. valve and bombarding the glass. Once the glass surface (or any film on it) becomes positively charged, the chance of further high-velocity electrons reaching it increases cumulatively. This effect, which produces fluorescence spots in E.H.T. tubes, may well cause the liberation of gas at internal "hot spots" in small transmitting valves if sufficient high-velocity electrons reach the glass. The shield would have the effect of stabilising the charges on the glass and reducing local heating.

I should add that I am indebted to Mr. B. S. Gossling, of these Laboratories, for the suggestion that secondary emission might be of importance.

Research Laboratories of the General Electric Co., Ltd., Wembley. E. C. S. Megaw.

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* *Reviews of Modern Physics*, Vol. 2, No. 2, p. 174 (April, 1930).

† *G. E. Review*, Vol. 23, p. 589 (1920).

# Books Received.

The National Physical Laboratory, Collected Researches, Vol. XXII, 1930.

A collection of authoritative articles on various wireless subjects which have occupied the attention of the N.P.L. during the past year. The writers include F. M. Colebrook, R. M. Wilmotte, H. A. Thomas, D. W. Dye, E. H. Rayner, S. W. Melsom, A. H. M. Arnold, L. Hartshorn, and J. E. P. L. Vigoureux. Published by H.M. Stationery Office. Price £1 net.

The Cable and Wireless Communications of the World (2nd Edition revised), by F. J. Brown, C.B., C.B.E., M.A., B.Sc.

A survey of present-day means of international communication by cable and wireless, including a chapter on State *versus* private enterprise and one on International Broadcasting. Pp. 153 + 24, with map and 20 illustrations and diagrams. Published by Sir Isaac Pitman & Sons, Ltd., London. Price 7s. 6d. net.

Données Numériques de Radioélectricité.

Compiled by R. Mesny, and extracted from Vol. VII of Tables Annuelles de Constantes et Données Numériques. Comprising 18 pages of useful formulæ and data taken from standard publications during the years 1925–1926. Published by Gauthier-Villars & Cie, Paris, and by McGraw Hill Book Co., Inc., New York. Price: Paper, Fcs. 35; Cloth, Fcs. 40.

The Theory and Practice of Radio Frequency Measurements.

A Handbook for the Laboratory and a Text-book for advanced students. 2nd Edition entirely reset and enlarged, and including a new chapter developing the electromagnetic equation and calculating the field near circuits and aerials. Pp. 487, with 284 diagrams and illustrations. Published by Charles Griffin & Co., Ltd., London. Price 34s. net.

Practical Radio Repairing Hints. By John F. Rider.

A useful book of data for the Radio-service man, experimenter and amateur, giving concisely the problems usually encountered in overhauling and repairing receivers, with a chapter on simple tests and hints. Pp. 262, with 208 diagrams and curves. Published by Radio Treatise Co., Inc., New York.

Der Bau von Überlagerungsempfängern (Building the Superheterodyne Receiver). By Dr. Walter Daudt.

The theory of the superheterodyne and practical directions for building a typical receiver. Pp. 48, with 40 illustrations and diagrams, and a sheet of the symbols used in wireless diagrams. Published by Rothgiesser und Diesing A.G., Berlin. Price RM. 1.50.

# Abstracts and References.

Compiled by the Radio Research Board and reproduced by arrangement with the Department of Scientific and Industrial Research.

## PROPAGATION OF WAVES.

A Method of Measuring Upper Atmospheric Ionisation.—E. V. Appleton. (*Nature*, 7th Feb., 1931, Vol. 127, p. 197.)

"The experimental investigation of the electrical structure of the upper atmosphere by means of wireless waves as the exploring agency has shown that there exist two main ionised regions from which such waves may be reflected. The lower of these regions is the Kennelly-Heaviside layer, which reflects long waves in long-distance transmission. The upper region is found to be much richer in ionisation than the lower, so that if we project vertically upwards waves of gradually increasing frequency (and therefore gradually shorter wavelength) we find that, at a certain critical frequency, the lower region is just penetrated and reflection takes place from the upper region.

"In experiments carried out during the last twelve months it has been found that the value of this critical frequency is surprisingly definite and therefore can be taken as a measure of the ionisation content of the lower region."

The relation between the critical frequency $f$ and the value $N$ of the maximum number of electrons per c.c. is found to be

$$N = \frac{3\pi m}{2e^2}(f^2 + ff_H),$$

where $e$ and $m$ are the electronic charge and mass and $f_H = \dfrac{H_0 e}{2\pi mc}$ ($H_0$ = earth's magnetic field, $c$ = velocity of light *in vacuo*), for any direction of propagation relative to $H_0$.

An experimental technique has been developed which permits one determination of $f$ in a period of an hour, and a recent twenty-four hour run has shown that "for a mid-winter day over southern England the value of $N$ reaches $2.0 \times 10^5$ electrons per c.c. at noon, after which the value falls steadily and remains at the low value of $3 \times 10^4$ during the greater part of the night. About half an hour before sunrise a very sharp increase is noted, after which the ionisation increases more gradually until the maximum midday value is again reached. The noon value of ionisation is thus found to be more than six times the midnight value.

"The diurnal variation curves bear a pronounced resemblance to theoretical curves deduced by Professor S. Chapman [*see* below] for a case of atmospheric ionisation by monochromatic radiation."

The Absorption and Dissociative or Ionizing Effect of Monochromatic Radiation in an Atmosphere on a Rotating Earth.—S. Chapman. (*Proc. Physical Soc.*, 1st Jan., 1931, Vol. 43, Part 1, pp. 26–45.)

"The main purpose of the present paper . . . is not to discuss the actual state of ionization of the atmosphere on the basis of the scanty available data; it is intended to afford a means of discussing the value and variations of the ion-content of the upper atmosphere when reliable data become available. Its results are applicable not only to the ionized layer near 100 km., but also to the higher layer, at about 250 km., discovered by Appleton; the values of the constants . . . for the two layers may, and probably will, be different." The present analysis is applicable also to the absorption of non-ionizing radiation, such as that which leads to the formation of ozone; but the later sections are valid for dissociating-radiation only if the products of dissociation recombine according to the simple law $dn/dt = I - an^2$, which may not be the case for ozone.

An atmosphere of uniform composition is assumed, in which the density varies exponentially with height. The components are supposed to recombine with one another alone, and not to diffuse away from the element of volume in which they were formed. A constant recombination coefficient is assumed, and the results are illustrated by numerous diagrams, showing the density of the dissociation products as a function of height, time of day, latitude and season. *Cf.* Appleton, above.

Über die Fortpflanzung von Signalen in dispergierenden Systemen. Zweiter Teil: Verlustarme kontinuierliche Systeme (On the Propagation of Signals in Dispersive Systems. Part II: Continuous Systems with Small Losses).—H. G. Baerwald. (*Ann. der Phys.*, Series 5, 1930, Vol. 7, No. 6, pp. 731–760.)

The second of a series of papers dealing with the mathematical theory of signal propagation in dispersive systems (*cf.* Jan. Abstracts, p. 32). A critical discussion is given of the idea and importance of signal velocity in its dependence on depth of penetration into the dispersive medium. In the case where the losses are finite but very small, there is always a finite "critical depth" below which the signal velocity has no meaning. The course of the signal is then quite different from that in a system with zero loss and is of a transitory nature: the order of magnitude of this "critical depth" is given as a function of the steady frequency.

A special study is made of the cases in which the main frequency lies near a boundary frequency or region of selective absorption.

Nabludenia nad zamiraniem signalov korotkovolnih stancy (Observations on the Fading of Short Wave Radio Signals).—A. N. Shtchukin. (*Westnik Elektrot.*, No. 5, 1930, Part I, pp. 163–172.)

In Russian. A preliminary report on investigations carried out since 1928 by the State Technical

Laboratory of Leningrad. Observations have been made on signals received from a number of radio stations operating within the wavelength band from 15 to 40 metres and located between 2,000 and 2,500 kms. from Leningrad. Observations have been confined to the periods from 4 hours before to 4 hours after sunset in Leningrad. The apparatus used for recording the signals consists essentially of a radio receiver, the audio-frequency output of which is rectified and used to operate a mirror galvanometer, whose movements are recorded on a moving sensitised tape. About 200 curves have been obtained in this way and examined with the following results :—

(I) While the ratio between the maximum and minimum amplitude lies between 20 and 40, the average signal strength over periods as short as 15 to 20 minutes does not vary by more than 30 %.

A comparison between the vertical and horizontal components of the received wave showed that the ratio between these varied from 2 to 4. These components were compared by connecting the receiver alternately for one minute periods to vertical and horizontal antennae.

(II) Many curves show definite periodicity of fading, the periods being usually of the order of 3 to 7 seconds. The regularity in fading and the constancy of the average signal strength support the view that fading is due to interference between several rays propagated along different paths. When fading becomes more irregular it would appear that certain changes are taking place in the reflecting layer [*cf.* Merritt, next abstract]. The number of separate rays is small and tends to decrease (*a*) as the wavelength is reduced ; (*b*) with the approach of night ; and (*c*) when directive transmitting antennae are employed.

Two receiving equipments connected respectively to vertical and horizontal antennae and recording signal strength curves on the same tape were used to investigate fading due to the rotation of the planes of polarization of the incoming waves. It was found that (*a*) fading due to this cause occurs as frequently as that due to interference ; (*b*) that it is more regular ; the two curves are of sinusoidal shape and displaced by approximately 180 deg. ; and (*c*) that the periods of fading vary from one second to several minutes.

It is shown mathematically that fading with a period of a few seconds is probably due to interference of several rays with rotating planes of polarization, while fading with a period of several minutes is probably produced by the rotation of the plane of polarization of a single ray whose intensity is much higher than that of other rays.

(III) Signals differing in frequency by 6 to 20 kc. and radiated by the same transmitter were found to fade practically simultaneously.

(IV) Signals received on two receivers connected to directive antennae spaced from 10 to 30 metres apart were also found to fade simultaneously.

The practical conclusion drawn from this evidence is that the effects of fading cannot be satisfactorily overcome either by modulating the carrier with audio-frequency or by using two receiving antennae separated by distances of the order of one wavelength.

THE OPTICS OF RADIO-TRANSMISSION.—E. Merritt. (*Journ. Opt. Soc. Am.*, Feb., 1931, Vol. 21, pp. 90–100.)

In the course of this non-mathematical survey, the writer points out that the diameter of the frame aerial is often less than 1 % of the wavelength it receives, and that this makes it possible to study the details of a radio wave pattern in a way hardly possible with visible light. He has recently been studying in this way the " fine structure " of a wave front : the results are " both interesting and puzzling." Two frame receivers were placed at two points on the wave front about half a wavelength apart, and their two sets of signals brought by cables to a cathode-ray oscillograph, one set producing a horizontal deflection and the other a vertical.

The amplitude and phase relations between the oscillograph deflections were the same as those between the original magnetic fields at the two receivers (*cf.* Merritt and Bostwick, 1929 Abstracts, p. 144) ; both phase and amplitude might naturally be expected to be the same at the two points on the same wave front—in which case the spot would trace a straight line at 45 degrees. Sometimes this line was observed ; *usually it was not*, but rather an ellipse changing from moment to moment in size and shape, sometimes so rapidly and erratically that it was impossible to follow the changes. Unless the conditions were exceptionally steady, the results were much the same whether the signals came from a great distance or from a station only 50 miles away. The changes were much less marked when the two frames were set with their planes directed towards the station, when the received signal was chiefly that carried by the ground wave.

After discussing the desirability of attempting to build up a picture of the radio wave train on the basis of modern corpuscular theory, the writer decides that although such a change of treatment may ultimately be necessary, it is at present best to keep to the classical ideas. " When the conditions for radio reception are bad it seems probable that something is going on in the upper atmosphere which is at least analogous to the convection currents in heated air."

NOTE ON SKIP DISTANCE EFFECTS ON SUPER-FREQUENCIES [30–40 MEGACYCLES PER SEC.].—A. Hoyt Taylor. (*Proc. Inst. Rad. Eng.*, Jan., 1931, Vol. 19, pp. 103–105.)

Naval Research Laboratory measurements, mostly during the first three months of 1929 and 1930, in daylight hours, and largely in a general southerly or south-westerly direction. The transmitters were from 500 to 1,000 w. in power, sometimes used on doublets and sometimes on beam systems concentrating the energy approximately within a cone 25 deg. in diameter.

The midday skip distance in nautical miles for 20 megacycles is given as 800 ; for 32 mc., 1,800 ; for frequencies in between, the skip distances correspond ; for 36 and 40 mc., they are entered as " greater than 1,800 miles " and it is stated that " as far as 40 mc. is concerned, only a small number of contacts were obtained on this frequency, so that it can be said in general that it is usually above the practical limit for long-distance communication."

Diurnal and day-to-day variations are discussed. Magnetic storms usually threw out the entire table by a very considerable amount, generally, however, shortening the skip distance. The minimum skip distance occurred generally 1 to 1½ hours after noon. No variation of skip distance was observed on changing from aerial to beam, "which merely indicates that the general assumption, that only low angle radiation is profitable on these frequencies, is correct." No material difference, also, was found between beams horizontally and vertically polarised.

"There is reason to suspect that on these upper frequencies transmissions east and west differ quite radically from those north and south. However, within the first zone of reception (which would be inside of 2,000 miles) there is no reason to suspect that there is a very radical departure from the skip distances given in the table"—such observations as were obtainable in the east and west direction showing a fair agreement with the north and south results.

KENNELLY-HEAVISIDE LAYER STUDIES.—P. A. de Mars, T. R. Gilliland, and G. W. Kenrick. (*Proc. Inst. Rad. Eng.*, Jan., 1931, Vol. 19, pp. 106–113.)

Authors' summary:—This paper describes progress in a recently inaugurated program of co-operative research for the study of radio transmission. Oscillographic observations of pulse transmissions made at the Bureau of Standards and Tufts College, in collaboration with workers at the Naval Research Laboratory and the Department of Terrestrial Magnetism, are discussed. Observations on 1,410 kc. and a number of higher frequencies are described, and oscillograms showing the complex phenomena frequently encountered in night transmission are shown. Evidence in support of the existence of several ionized strata, such as postulated by Appleton and Eckersley, is found, and examples of the pulse distortions frequently encountered in reflection or refraction are shown. The paper is presented merely as a preliminary report, and solicits the co-operation of others interested in observations of this type. The need of extended observations of varied types is emphasised, and a more extended quantitative discussion of results is reserved for a later communication when more data are available.

KENNELLY-HEAVISIDE LAYER HEIGHT OBSERVATIONS FOR 4,045 KC. AND 8,650 KC.—T. R. Gilliland. (*Proc. Inst. Rad. Eng.*, Jan., 1931, Vol. 19, pp. 114–119.)

*See* February Abstracts, p. 88.

THE UNEQUAL FADING OF CARRIER AND SIDE BANDS.—A. W. Ladner: G. Wilde: T. L. Eckersley. (*Marconi Rev.*, Jan.–Feb., 1931, pp. 25–27.)

A discussion, started by the first writer's paper dealt with in 1930 Abstracts, p. 623, on the question whether unequal fading of modulated component and carrier can occur in single side band transmission with carrier re-introduced in the demodulator. The Rugby long wave transmissions would not, in any case, be much troubled by this type of fading, and suppressed carrier transmission attempts on short waves have failed on account of insufficient frequency stability [Eckersley]: experiments at Terling, however, showed that receptions were much better from the fading point of view [Ladner]. Whether the main cause of this type of fading is different amplitude fading of side waves relative to carrier, or relative phase shift, Eckersley is not prepared to say: but there is an effect akin to it which he is convinced is due to relative phase shift of the side bands, showing itself "as an apparently more or less permanently reduced modulated component [rectified beat tone between side waves and carrier] as compared with the carrier, and especially liable to occur within the skip distance." It is to be expected that in a scattering field the phase of the side bands would be changed by a random amount. He also remarks that a frequency modulation may produce an audio note in a receiver which will fade differently from the carrier.

INFLUENCES DE L'ATMOSPHÈRE SUR LES ONDES ULTRA-COURTES (Influences of the Atmosphere on Ultra-Short Waves).—G. Beauvais. (*Assoc. franç. p. l'Av. des Sci.*, 53rd Session, pp. 322–323.)

The stations of the France-Corsica service are 200 km. apart and the tangent lines from the two stations meet the surface of the sea at points some 15 km. apart, so that the stations are not "in sight" of each other. Nevertheless good duplex telephony is obtained on 5.3 and 6 metre waves, with 35 w. input to the valves; normal reception is audible more than a metre from the telephones.

On certain days, however (always very sunny ones), either towards midday or during the afternoon signals are subject to a progressive weakening followed by a gradual return to normality, the whole phenomenon lasting several hours. The effect, when it occurs, applies equally to the 5.3 and 6 m. waves, and to the 3.75 m. wave on which tests were also made. No such weakening occurs after sunset.

SUR LA CONSTANTE DIÉLECTRIQUE ET LA CONDUCTIBILITÉ DES GAZ IONISÉS (The Dielectric Constant and Conductivity of Ionised Gases).—Th. V. Jonescu and C. Mihul. (*Comptes Rendus*, 9th Feb., 1931, Vol. 192, pp. 343–345.)

The measurements of dielectric constant $\triangle C$ and conductivity $\frac{1}{\rho}$ described in a previous Note (March Abstracts, p. 144) gave values 30 times greater than are indicated by calculation. This fact has led the writers to investigate the condition of the electrons in their tube when the potential difference of the plate with respect to the ring is varied, by an amount $\triangle v$, between $+ 450$ and $- 450$ volts, the ring being maintained at 1,600 volts. The curves of the plate and ring currents indicate that for $\triangle v = - 150$ v. all the electrons formed between ring and plate are caught by the ring; for $\triangle v = + 150$ v. they are caught by the plate. For values above $+ 150$ v., electrons are formed between filament and ring, and traversing the space between ring and plate are captured by the latter.

Curves are given for $\triangle C$ and $\frac{1}{\rho}$ plotted against various values of $\triangle v$, for four wavelengths ranging from 2.32 to 10.07 metres. All the curves are asymmetrical owing to the additional electrons mentioned above, formed between filament and ring. The $\frac{1}{\rho}$ curves for 2.32 and 4.55 m. waves are comparatively flat, but the 7.18 and 10.07 m. curves show a marked peak round $\triangle v = 0$. The $\triangle C$ curve for 2.32 m. is almost flat, that for 4.55 m. shows a distinct negative peak round $\triangle v = 0$, and the 7.18 and 10.07 m. curves show very pronounced negative peaks there. "The results can be explained on the supposition that the electrons are associated with molecules and by virtue of this fact possess a natural period of vibration. . . . If $\triangle v$ is sufficiently raised, a large number of these associations are destroyed, and the electrons detach themselves from the molecules and produce the effects of free electrons. Similarly the great range of short electric waves, between 10 and 40 metres in length, can be explained by supposing that the upper atmosphere contains electrons associated with molecules and possessing the same natural period as that mentioned above."

Sur les Perturbations diurnes de la Réfraction (The Diurnal Disturbances of Refraction [in the Atmosphere]).—Th. Banachiewicz. (*Comptes Rendus*, 26th Jan., 1931, Vol. 192, pp. 219–221.)

The Timing of Wireless Echoes.—E. V. Appleton. (*Wireless World*, 7th and 14th January, 1931, Vol. 28, pp. 2–4 and 43–44.)

The second half of the article deals with the effect of echo phenomena on television and picture telegraphy.

Radio Field-Strength Survey of the City of Calcutta and its Suburbs.—H. Rakshit. (*Phil. Mag.*, Jan., 1931, Series 7, Vol. 11, No. 68, pp. 174–184.)

The results of a quantitative radio field-strength survey with frame aerial of Calcutta and its suburbs is given and a contour map is drawn showing lines of equal field strength. It is observed that the attenuation of the waves over land is much greater than that over water. Loops occur in the contour map giving sharp minima of field strength, which are attributed to interference between waves coming from different directions. Elevated structures are found to cause local shadows. No reference is made to the shape of the transmitting antenna. The observations were made on the local broadcasting station VUC (370.4 m.).

Some Notes on Field-Strength Measurement.—A. L. Green. (*E.W. & W.E.*, Feb., 1931, Vol. 8, pp. 61–69.)

Author's summary :—During the course of "fading" observations at Radio Research Station, Peterborough, it was realised that the absolute strength of atmospherically-returned wireless waves could be calculated from a knowledge of (*a*) the field strength of the steady ground wave in daylight, and (*b*) any "fading" curve taken at night. The following notes are a record of some attempts made at Peterborough to measure field strengths as low as 0.5 millivolt per metre, with simple unshielded apparatus. A high standard of accuracy has not, so far, been attempted, but the results already obtained indicate a useful field for development.

La Dispersion des Ondes hertziennes dans les Solides (The Dispersion of Hertzian Waves in Solids [Seignette Salt, etc.]).—J. Errera. (*Comptes Rendus*, 26th Jan., 1931, Vol. 192, pp. 223–225.)

Contrary to the results of Frayne, Kobeko and Kurtschatov, the writer's tests show a marked dependence of s.i.c. on frequency. Tests on the crystal showed an anomalous dispersion at a frequency corresponding to its vibration frequency, but compressed crystal powder gave a steady increase of $\epsilon$ with decreasing frequency, without any anomaly.

The curves taken on the crystal show that for a constant *low* frequency (*e.g.*, 2,300 cycles/sec.) $\epsilon$ increases with the value of a.c. field—since the free Debye dipoles increase in number : this explanation is confirmed by the simultaneous decrease in ohmic resistance. Superposition of a d.c. field on a constant a.c. field diminishes the s.i.c. and the conductivity. Similar results, but in a much smaller proportion, appear in the compressed powdered salt, and also in ice and solid nitrobenzene.

Polarisation elliptique par Réflexion à la Surface des Liquides : Application à l'Étude des Couches monomoléculaires superficielles (Elliptical Polarisation by Reflection at Liquid Surfaces : Application to the Study of Superficial Monomolecular Layers).—Ch. Bouhet. (*Ann. de Physique*, Jan., 1931, Vol. 15, pp. 5–130.)

Wavelength Change of X-Rays passing through an Absorbing Medium.—J. M. Cork : B. B. Ray. (*Comptes Rendus*, 19th Jan., 1931, Vol. 192, pp. 153–155.)

## ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

Atmospherics in Ultra-Short Wave Services.—G. Beauvais. (*Assoc. franç. p. l'Av. des Sci.*, 53rd Session, p. 323.)

The France-Corsica service has shown once again that ultra-short waves are practically untroubled by atmospherics, except during local storms, when they occur just at the moment of the lightning-flash. On one single occasion, 6-metre reception at the Nice station was made impossible by a storm immediately overhead ; the static charge of the full-wave aerial (highest point 7 m. above the ground) caused discharges between the coupling coils. But simultaneously it was found perfectly possible to receive a 3.75 m. wave on a full-wave aerial whose highest point was less than 5 m. above ground.

NOTE ON A PHENOMENON CONNECTED WITH THE AURORA.—A. C. Burton. (*Canadian Journ. of Res.*, Jan., 1931, Vol. 4, pp. 52–53.)

" A narrow and distinct arch of light was observed to stretch across the sky overhead from East to West, remaining steady in position for some forty minutes. A photograph, on microscopic examination, showed an unexpected fine structure that was not observed visually." This fine structure consists of parallel lines : assuming a height of 500 miles, two of these would be about 400 yards apart and are accurately parallel for 100 miles.

SIMULTANEOUS ATMOSPHERIC AND CABLE DISTURBANCES.—M. Bäumler. (*Proc. Inst. Rad. Eng.*, Jan., 1931, Vol. 19, pp. 138–144.)

English version of the paper dealt with in 1930 Abstracts, p. 624.

WHISTLING TONES FROM THE EARTH : DISCUSSION. —A. M. Curtis : H. Barkhausen. (*Proc. Inst. Rad. Eng.*, Jan., 1931, Vol. 19, p. 145.)

Referring to Barkhausen's paper (1930 Abstracts, pp. 622–623), Curtis describes some Newfoundland observations on " swishes " and " tweeks "—*see also* Burton, Jan. Abstracts, p. 34, and Meyer's criticism.

L'ÉVOLUTION RÉCENTE DE LA MÉTÉOROLOGIE ÉLECTRIQUE ET DE SES MÉTHODES (Recent Evolution of " Electrical Meteorology " and Its Methods).—R. Bureau. (*Assoc. franç. p. l'Av. des Sci.*, 53rd Session, pp. 287–293.)

In the latter part of this Presidential address to the Meteorology Section, Bureau asks leave to review in his official capacity the present position of beliefs regarding atmospherics, in which as the leader of the French " school " he has been personally in disagreement with the English " school " (Watson Watt, Appleton and Herd). It can no longer be denied, in face of the results obtained by the latter school (which are, moreover, confirmed by recent results in France) that the violent atmospherics met with on certain summer afternoons come from thunderstorms and their lightning flashes, which produce exactly corresponding atmospherics at stations many hundreds of kilometres apart. When Bureau maintained that this hardly ever occurred he was drawing too hasty conclusions and was misled, also, by results obtained on two short a base line.

But provided Bureau is ready to admit the possibility of world-wide atmospherics coming from " a land where it is always summer afternoon " (Watson Watt, 1929 Abstracts, p. 324) he does not seem to have been wrong in maintaining, for five years or more, the predominant importance of cold fronts in producing atmospherics and of warm fronts in destroying them. What, however, he must admit and has not always admitted, is that the action of meteorological changes in moderate latitudes is *not* purely local but may have a large range, perhaps even greater than that of the tropical storms.

In their attitude towards those who urge the *cosmic* origin of atmospherics, Bureau and Watson Watt find themselves on the same side. The ardent supporters of this theory (and they still exist) must be associated with the believers in the ionised layer as the source of numerous atmospherics. It is difficult to say that this last theory is entirely wrong ; even Watson Watt, convinced believer in the troposphere as the almost exclusive source of atmospherics, has put on record the observation of atmospherics linked with certain magnetic disturbances, and the Poulo Condore observations showed a marked effect of the eclipse on the régime of atmospherics. But such action on the part of the ionised layers might be expected, since the reception of atmospherics depends not only on their production but also on their propagation. " In [the study of] propagation we have a means of comparing the phenomena of the ionised layers and of the troposphere. I believe I have thus shown, in a paper now being printed, that they may be very closely linked, and that the great perturbations of the polar front reverberate as far as the ionised layers."

DIRECTIONAL RECORDER FOR ATMOSPHERICS.—Bureau.

(*See* under " Directional Wireless.")

L'ENREGISTREMENT DES ATMOSPHÉRIQUES À SAINT-CYR ([Apparatus used in] the Recording of Atmospherics at Saint Cyr).—P. Dowry : R. Bureau. (*Assoc. franç. p. l'Av. des Sci.*, 53rd Session, pp. 293–296.)

A combination registering not only the frequency of atmospherics but also their intensity.

DE L'INFLUENCE DU CHAMP MAGNÉTIQUE TERRESTRE SUR LES ATMOSPHÉRIQUES DE LA TÉLÉGRAPHIE SANS FIL (The Influence of the Earth's Magnetic Field on the Atmospherics encountered in Wireless).—F. Schindelhauer. (*Assoc. franç. p. l'Av. des Sci.*, 53rd Session, pp. 300–304.)

A concise exposition of the writer's results and conclusions, already set out in the various papers dealt with in Abstracts, 1929, pp. 101 and 503, and 1930, p. 389.

SPECIMEN RECORD OF ATMOSPHERICS ON THE ATLANTIC.—G. H. Huber. (*Assoc. franç. p. l'Av. des Sci.*, 53rd Session, pp. 298–299.

A record (between New York and Martinique) coinciding with the passage of a disturbance of cyclonic type bringing with it a succession of squalls (occlusion of a cumulo-nimbus) each of which was accompanied by a recrudescence in atmospherics. Such phenomena are probably frequent in this region and perhaps explain why the Americans trace their atmospherics to it.

RELATIONS BETWEEN ATMOSPHERICS AND METEOROLOGICAL PHENOMENA AT SAINT CYR.—–. Buffault. (*Assoc. franç. p. l'Av. des Sci.*, 53rd Session, pp. 296–298.)

Cloud types and their influence on atmospherics : electrification of the aerial—the passage of the front of a cumulo-nimbus is often accompanied by a temporary increase in atmospherics and an electrification of the aerial (ceasing at the first drops of rain—perhaps because of the decrease in insulation): hail often produces cracklings which on three occasions ceased on the occurrence of a lightning flash and gradually returned. "According to Angot's theory, hail-stones forming at the lower part of the cumulo-nimbus would be positively electrified, and the ionisation produced in the air by a lightning flash should not make them lose their charge: the cause of this crackling must therefore be sought elsewhere than in the fall of the electrified hail-stones."

Atmospheric Ionization by Cosmic Radiation.—E. O. Hulburt. (*Phys. Review*, 1st Jan., 1931, Series 2, Vol. 37, No. 1, pp. 1–8.)

Author's summary:—From Millikan's measurements of the intensity and the absorption coefficients of cosmic radiation the ionization in the atmosphere is calculated from sea level to 60 km. The electron density is negligibly small in this region. The ion density increases with the height to $3.5 \times 10^3$ ion pairs $\text{cm.}^{-3}$ at about 50 km. and is roughly constant above this to 60 or 70 km. where the solar ultraviolet light ionization sets in. The 50 km. ion bank refracts appreciably radio waves longer than 12 km. and being unchanged with the day and night accounts for the propagation of waves longer than 12 km., which are known to show no marked diurnal variations. The agreement with the facts of long radio waves indicates that there exists in the high atmosphere but little cosmic radiation of less penetration than Millikan has already detected.

By considering the effect of the earth's magnetic field on high speed electrons, the "run away" electron hypothesis of C. T. R. Wilson to account for cosmic radiation is shown to lead to a distribution most intense at low latitudes and feeble at high latitudes, thereby being in disagreement with Millikan's observation of the constancy of the cosmic radiation with latitude.

Spectrum of Cosmic Rays.—E. Regener. (*Nature*, 14th Feb., 1931, Vol. 127, pp. 233–234.)

The cosmic rays have been followed to a depth of 236.5 m. in experiments on the absorption of cosmic rays in Lake Constance. "Analysis of the absorption curve showed four components of different penetrating power." "According to Klein and Nishina's formula, the wavelength of the hardest component is $0.63 \times 10^{-13}$ cm., whereas the complete transformation of a proton and an electron into radiation would correspond to a wavelength of $1.313 \times 10^{-13}$ cm."

Remarks on a Paper "Note on the Nature of Cosmic Rays," by Paul S. Epstein.—C. Störmer. (*Proc. Nat. Acad. Sci.*, Jan., 1931, Vol. 17, pp. 62–63.)

Pointing out that Epstein's equations correspond to the ones in Störmer's 1904 paper on the Polar Aurora: that a complete discussion of the regions of the earth hit by the cosmic rays, and also a study of the trajectories of these rays down to the earth, can be made exactly on the same lines of research as those developed in his mathematical theory of aurora, and that the surface given by the equation in Epstein's paper is nothing else than the toroidal surface playing such an essential part in Störmer's explanation of the Wireless echoes of long delay (1929 Abstracts, p. 144, and elsewhere).

Wo erreichen kosmische Elektronenstrahlen die Erdkugel? (Where do Cosmic Electron Beams strike the Earth?)—E. Brüche. (*Physik. Zeitschr.*, 1st Jan., 1931, Vol. 32, No. 1, pp. 31–33.)

Periodische Elektronenbahnen im Felde eines Elementarmagneten und ihre Anwendung auf Brüches Modellversuche und auf Eschenhagens Elementarwellen des Erdmagnetismus (Periodic Electron Paths in the Field of an Elementary Magnet, and their Application to Brüche's Model Tests and to Eschenhagen's Elementary Waves of Terrestrial Magnetism).—C. Störmer. (*Zeitschr. Astrophys.*, Nov., 1930.)

Zur Methodik der Ionenzählung in der freien Atmosphäre (On the Theory of a Method of Ion Counting in the Free Atmosphere).—Yo Itiwara; *and* Bemerkungen zur vorstehenden Arbeit des Herrn Yo Itiwara (Remarks on the Foregoing Paper by Mr. Yo Itiwara).—V. F. Hess. (*Physik. Zeitschr.*, 15th Jan., 1931, Vol. 32, No. 2, pp. 97–106.)

Optische Untersuchung der Funkenzündung in Luft von Atmosphärendruck mittels des Kerreffektes (Optical Investigation of Spark Discharge in Air at Atmospheric Pressure by means of the Kerr Effect).—L. v. Hámos. (*Ann. der Phys.*, Series 5, 1930, Vol. 7, No. 7, pp. 857–888.)

See also 1930 Abstracts, p. 471.

Some Considerations on the Artificial Production of Rain.—N. A. Bulgakov. (*Westnik Elektrot.*, Nos. 3 and 4, 1930, pp. 104–109 and 147–151.)

In Russian. The writer applies his formulae for the motion of a point, attracted to a centre by a force $\mu/r^2$ and encountering a resistance $2\,kv$, to the mutual attraction between a heavy electrically-charged dust particle and an ionised drop, on the assumptions that by the influence of wind the surrounding air moves progressively on a definite law and that the vertical columns of air near the drop and the particle have an independent motion and compensate the action of gravity.

It is found that for a regular scattering of dust particles on a horizontal plane, drops in a cloud spaced 1/20 cm. would *all* be attracted to the dust particles within 2 hours.

In a constant electric field, unequally charged drops may agglomerate; an example is given of a specially favourable distribution of charges, when all drops will amalgamate in half an hour for a field intensity of 1 c.g.s. unit. In alternating fields the agglomeration is only possible in the case of damped waves, and the corresponding time would be 2½ hours for 1 c.g.s. unit. Such a field intensity would only occur near the aerial system of a station more powerful than Nauen. Theoretically, the reciprocal action of induced charges may be effective, but the field intensity would then be of the order of 10 c.g.s. units. The American tests are discussed, in which the air gap in a condenser formed by the ground and the charged upper layer of the atmosphere was to be disrupted by radio waves.

## PROPERTIES OF CIRCUITS.

K VOPROSU O ZATUHANII I SELEKTIVNOSTI REGENERATIVNOGO PRIEMNIKA (Selectivity and Damping in a Regenerative Radio Receiver).—E. S. Antseliovitch. (*Westnik Elektrot.*, No. 5, 1930, Part I, pp. 194–196.)

In Russian. A mathematical analysis is presented of selectivity and damping in a regenerative circuit.

When the reactive coupling is critical the current $I_g$ in the grid circuit is given by the following expression which is deduced in a previous paper by the author* :—

$$I_g = \frac{V_g}{R_1 \sqrt[3]{\left(\frac{\mu\rho V_g}{2R_1E_0}\right)^2}}.$$

where $V_g$ = grid voltage due to the incoming signal, $R_1$ = resistance of the grid circuit, $\mu$ = amplification factor of the valve, $\rho$ = a.c. resistance of the circuit, and $E_0$ = anode voltage.

When no regeneration is used $I_g = \frac{V_g}{R_1}$. Regeneration may thus be considered as equivalent to a reduction in the resistance of the grid circuit. The ratio $m$ of the actual resistance $R_1$ to the equivalent resistance $R_{\text{equiv.}}$ is

$$\sqrt[3]{\left(\frac{2R_1E_0}{\mu\rho V_g}\right)^2}.$$

The following formulae are then derived from this expression :—

$$\text{Coefficient of damping } \alpha = \frac{R_1}{2Lm}$$

Logarithmic decrement

$$\delta = \frac{\pi}{\sqrt[3]{\frac{\rho}{R_1}\left(\frac{2E_0}{\mu V_g}\right)^2}}$$

$$\cos\phi = \frac{\delta}{\pi} = \sqrt[3]{\frac{R_1}{\rho}\left(\frac{\mu V_g}{2E_0}\right)^2}.$$

It appears from these expressions that damping is dependent on the strength of the incoming signals, the resistance $R_1$ of the grid circuit, and the characteristics of the valve.

A general expression defining selectivity is next given :—

$$F = \frac{R}{2\pi L}\sqrt{n^2 - 1}$$

where $F$ is the width of the resonance curve between the points where the response is $\frac{1}{n}$ of the peak value. For the case of regenerative reception the following expression is derived :—

$$F = \frac{\alpha}{\pi m}\sqrt{n^2 - 1}.$$

Selectivity is thus also dependent on the strength of the incoming signals and the characteristics of the valve.

The conclusions arrived at are important inasmuch that the comparison of the damping and selectivity of different regenerative circuits are meaningless unless input signal strength and the characteristics of the valves used are the same in each case.

THE DETECTION OF TWO MODULATED WAVES WHICH DIFFER SLIGHTLY IN CARRIER FREQUENCY.—C. B. Aiken. (*Proc. Inst. Rad. Eng.*, Jan., 1931, Vol. 19, pp. 120–137; *Bell Tech. Journ.*, Jan., 1931, Vol. 10, No. 1, pp. 1–19.)

Author's summary :—The present paper contains an analysis of the detection of two waves modulated with the same, or with different, audio frequencies and differing in carrier frequency by several cycles or more. Both parabolic and straight line detectors are treated and there are derived the expressions for all of the important audio frequencies present in the output of these detectors when such waves are impressed. There are discussed the types of interference which result when one station is considerably weaker than the other and simple attenuation formulas are employed in estimating the character and extent of the interference areas around the two transmitters. Beyond the use of such formulas no attention is given to phenomena which may occur in the space medium such as fading, diurnal variations in field intensity, etc.

INVESTIGATION OF " ZIEHEN " EFFECT AND CRITICAL COUPLING.—S. G. Ginsburg. (*Westnik Elektrot.*, No. 9–10, 1930, pp. 283–294.)

In Russian. Author's abstract :—The " ziehen " effect [" back-lash " or coupling-hysteresis effect] and conditions for single periodicity of an electron tube oscillator having an intermediate circuit and coupling to the grid in the primary circuit are discussed. The condition for single periodicity, given for that case by Prince [*Proc. I.R.E.*, 1923] is confirmed experimentally. The " ziehen " effect, in an oscillator in the circuit taken, occurs in a different way from that usually accepted as a result of neglecting certain terms in the equations depending on the resistances of the circuits. Thus the condition for single periodicity given by Möller [*Zeitschr. f. hochf. Tech.*, 1920] is not true in general but satisfies a particular case only. The exact condition for single periodicity of the oscillator in question is deduced $\left(K_{cr} = \frac{2\sqrt{L_3L_4}}{n_3}\right)$ and proved experimentally.

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* E. S. Antseliovitch—The Design of the Regenerative Receiver (published by the Electro-Technical Institute, Leningrad).

Note sur le Calcul d'un Doubleur de Fréquence (Note on the Calculation of a Frequency Doubler).—B. P. Asséef. (*L'Onde Élec.*, Jan., 1931, Vol. 10, pp. 36–47.)

Apart from certain works which present the principal relations in a somewhat complex form (*cf.* Marique, 1929 Abstracts, p. 325) " we lack, almost entirely, material for the practical calculation of this important part of a short-wave transmitter." The writer deals with a single triode doubler only, but his method of treatment is also applicable to a two-triode doubler with grids in push-pull and anodes in parallel. He obtains formulae for :—(i) the amplitude of the a.c. component of the plate potential, (ii) the amplitude of the second harmonic of the plate current, (iii) efficiency, (iv) maximum value of the plate current, (v) saturation potential (putting the constant $A$, in the usual Barkhausen equation, as 8 for V-shaped filaments), (vi) the admissible value for the coefficient of utilisation of anode potential, *i.e.*, the ratio of the alternating anode voltage to the constant anode voltage, (vii, viii, ix and x) alternating and constant components of the various voltages, (xi) power consumed by the generator, (xii) mean value of anode current, (xiii) power dissipated at anode, (xiv) equivalent resistance of oscillating circuit.

A numerical example is given ; since a power of 120 w. is supposed to be wanted, an oscillator of the order of 240 w. is chosen, for practice and calculation alike show that the power obtainable from a valve used as a frequency doubler is about half that obtainable from it as an oscillator.

A Simplified Calculation of Valve Frequency Changers.—P. N. Ramlau. (*Westnik Elektrot.*, No. 3, 1930, pp. 109–114), *and* On Frequency Doubling by Electron Tubes.—V. J. Bunimovitch. (*Ibid.*, No. 4, 1930, pp. 133–143.)

Both in Russian. The second paper, after giving simple approximate formulae for input and output power, discusses practical circuits (single and push-pull triodes) and some secondary phenomena, such as feed-back, self-excitation, and regeneration on the doubled frequency. Calculated and experimental results are compared.

On the Operational Solution of Linear Finite Difference Equations [Theory applicable to Wave Filter Chains].—L. M. Milne-Thomson. (*Proc. Camb. Phil. Soc.*, Jan., 1931, Vol. 27, Part 1, pp. 26–36.)

Band-Pass Filters.—I. V. Koptev. (*Westnik Elektrot.*, No. 9–10, 1930, pp. 307–310.)

Inductive Band Pass Filters.—L. E. T. Branch. (*Wireless World*, 28th January, 1931, Vol. 28, pp. 78–81.)

Putting the case for coupling by the mutual inductance method. It is shown that the resulting filter lends itself to a simple and inexpensive layout in which unscreened coils are used.

Système " Rejecteur de Bande " Hopkins (The Hopkins " Band Rejector " System).—P. Leroy. (*L'Onde Élec.*, Jan., 1931, Vol. 10, p. 4A.)

Summary of a *Radio News* article on inter-stage couplings involving wave-trap circuits, leading to the production of a curve approaching the ideal rectangular shape. The reviewer points out that the circuits shown are only simplifications of those indicated by Blanchard (*L'Onde Élec.*, Feb., 1927).

The Tuned-Anode Coupling.—S. O. Pearson. (*Wireless World*, 7th January, 1931, Vol. 28, pp. 20–22.)

The theory of the tuned-anode arrangement, with equations and formulae for the calculation of its dynamic resistance, voltage amplification and selectivity.

The Intermediate Frequency Amplifier of the Superheterodyne.—A. L. M. Sowerby. (*Wireless World*, 17th and 24th Dec., 1930, Vol. 27, pp. 689–692 and 712–715.)

The causes and prevention of distortion, and a study of the relative merits of different frequencies.

The Inductance Coefficients of a Part of a Circuit, and their Applications [in connection with Cables and their Sheaths].—A. Russell. (*Journ. I.E.E.*, February, 1931, Vol. 69, pp. 270–280.)

Choice of Characteristic Constants for Telegraph Lines and Circuits.—V. I. Kovalenkov. (*Westnik Elektrot.*, No. 9–10, 1930, pp. 279–283.)

In Russian. " Formulae giving the distribution of current and potential along a line with a short circuit at the end usually comprise four constants : $R$, $L$, $C$ and $G$. Instead of them, the author introduces four new constants, $\tau = \frac{1}{a\sqrt{LC}}$, $z = \sqrt{\frac{L}{C}}$, $\beta a$ and $\sigma a$, which are more convenient for calculations. $\tau$ and $z$ represent the scales of time and current respectively, while $\sigma a$ and $\beta a$ characterise the electromagnetic process in the line. Some numerical calculations are given, and the optimal conditions for a telegraph line with the usual receiving relays ($0.6 \leq \beta a \leq 1.05$) are established."

## TRANSMISSION.

Die Phasenverteilung in einem zusammengesetzten Röhrengenerator für ultrakurze Wellen (The Phase Relations in a Multi-Valve Generator for Ultra-Short Waves).—A. P. Stwolin [Stvolin]. (*Zeitschr. f. hochf. Tech.*, Jan. 1931, Vol. 37, pp. 18–21.)

German rendering of the Russian paper dealt with in 1930 Abstracts, p. 158.

Theory of the Internal Action of Thermionic Systems at Moderately High Frequencies [with a Reference to the B.-K. Oscillations].—Benham. (*See* under " Valves and Thermionics.")

THE PIERRET CIRCUIT [FOR ULTRA-SHORT WAVES].—(*Wireless World*, 28th January, 1931, Vol. 28, p. 81.)

An article on Pierret's circuit for obtaining wavelengths of the order of 0.12 metre, using sliding copper discs on the connecting wires to limit the part of the circuit in which oscillating currents flow. *See* also 1929 Abstracts, p. 149.

ÜBER GITTERSCHWINGLINIEN (Dynamic Grid Characteristics).—C. Hagen. (*Zeitschr. f. hochf. Tech.*, Jan., 1931, Vol. 37, pp. 1–7.)

Problems concerning valve oscillators are in many cases made easier to solve by the use of Möller's method of dynamic characteristics. The emission characteristic, $I_e^{osc.} = f(U_{control}^{osc.})$, which is the most frequently used, must be re-drawn with the help of the grid characteristic in those cases where the coupling is excessive and consequently the grid current has an important influence. The determination of the boundary between this condition and the normal state is of importance in connection with the economical working of the oscillator. The transition is generally supposed to take place at the point where the instantaneous values of anode and grid potentials are equal, but the researches described in the present paper show that this is not correct.

The writer arrives at two forms of definition of the transition point, one of which is

$$\kappa U_a^{osc.} + U_g^{osc.} = \kappa U_a^{dc} - U_g^{dc},$$

where $\kappa$ is the ratio of the momentary peak values of grid and anode potentials. This gives, as the limiting value for the oscillatory anode potential,

$$U_{a\,lim.}^{osc.} = U_a^{dc} - \frac{U_{sat.}^{dc}}{\kappa + D},$$

where $D$ as usual is the valve "durchgriff." The formula given by Möller (which is the same as this except that $\kappa$ is replaced by unity) is, however, satisfactory for rough calculation.

MODULATION BY IRON-CORED CHOKE COILS WITH BALLAST CIRCUIT.—(German Pats. 509614 and 511393, Lorenz, pub. Oct., 1930.)

For various improvements covered by these patents, see *Zeitschr. f. hochf. Tech.*, Jan., 1931, Vol. 37, p. 24.

MODULATION CIRCUIT WITH MODULATOR AND OSCILLATOR FILAMENTS EARTHED. (German Pat. 509528, Lubszynski, pub. 9th Oct., 1930.)

For a diagram of this arrangement see *Zeitschr. f. hochf. Tech.*, Jan., 1931, Vol. 37, p. 25.

IMPROVEMENT IN GRID-D.C. MODULATION.—(German Pat. 509615, Telefunken, pub. 14th Oct., 1930.)

With the usual circuit there is difficulty in finding a modulator valve of sufficiently small internal resistance. This is avoided by connecting an auxiliary source of current in series with the modulator.

SIMPLE ADJUSTMENT OF PORTABLE SHORT WAVE TRANSMITTER. (German Pat. 513184, Lorenz, pub. 24th Nov., 1930.)

For simplicity in a portable set either the aerial or the anode circuit is often un-tuned, but even so a double adjustment is necessary (for optimum working) since the coupling between the two circuits needs regulating. According to the invention, this is avoided by tuning the aerial circuit with a series condenser and coupling the circuits by a second condenser ganged to the first.

## RECEPTION.

SELECTIVITY AND DAMPING IN A REGENERATIVE RADIO RECEIVER.—Antseliovitch. (*See* under "Properties of Circuits.")

ADJUSTMENT OF REACTION [VOLUME CONTROL] BY AN OSCILLATING VALVE.—(German Pat. 506557, Koomans, pub. 5th Sept., 1930.)

A very smooth reaction adjustment is provided by this circuit, in which part of the anode circuit is shunted by a control valve circuit so adjusted as to give continuous oscillation. The adjustment is made by varying either the reaction condenser or inductance of this control circuit, or its tuning condenser.

REACTION AND THE BAND-PASS FILTER.—W. T. Cocking. (*Wireless World*, 10th December, 1930, Vol. 27, pp. 640–642.)

The conditions under which reaction can be usefully employed in a band-pass filter. It is shown that reaction considerably increases peak separation but that signal strength is not improved to the same degree as with a single tuned circuit.

LOW VOLTAGE POWER GRID DETECTION.—W. T. Cocking. (*Wireless World*, 3rd December, 1930, Vol. 27, pp. 618–621.)

The high initial voltage demanded by the parallel feed method of intervalve coupling used after a power grid detector has limited the use of this detector to receivers with available voltages of the order of 300. Information is here given on types of coupling necessitating initial potentials of only 200 v.

A SUPERHETERODYNE RECEIVER FOR SHORT WAVES.—R. W. Tanner. (*Rad. Engineering*, Jan., 1931, Vol. 11, pp. 22–23.)

In superheterodynes with a variable oscillator wavelength, a station can be brought in at two points on the oscillator dial. In the present type, the oscillator is semi-variable (*i.e.*, adjustable for different bands in the total wave-range) the tuning being done on the variable intermediate frequency circuit. Not only is the second beat eliminated, but tuning is no more critical at 20 m. than at 100 m.

THE STENODE.—J. Robinson. (*Wireless World*, 7th January, 1931, Vol. 28, pp. 9–11.)

The inventor's explanation of the Stenode Radiostat, together with some difficulties connected with the application of the sideband theory. An abstract of a paper read recently by Dr. Robinson before the Radio Club of America.

Modulated Continuous Waves and the Stenode Radiostat.—C. H. W. Nason. (*Rad. Engineering*, Jan., 1931, Vol. 11, pp. 19–21.)

" An engineering discussion of the theory of a new receiver system recently brought from England and demonstrated in New York." The writer ends by referring to Pearson's suggested explanation of the circuit's immunity to heterodyning interference (1930 Abstracts, p. 508) of which he says " It is the writer's opinion that the freedom from interference found will not be explained through this varying frequency premise taken by Mr. Pearson but that it may be found that the phasing of the various components constituting heterodyne interference will give the final explanation."

The Wireless World Four—Battery Model.—F. H. Haynes. (*Wireless World*, 17th December, 1930, Vol. 27, pp. 672–677.)

Receiving Sets of To-day.—(*Wireless World*, 19th November, 1930, Vol. 27, pp. 572–575.)

An analytical study of modern commercial designs, classified under various heads. These include number and arrangement of valves, method of detection, current supply, tuning control, etc.

## AERIALS AND AERIAL SYSTEMS.

Beam Arrays and Transmission Lines.—T. Walmsley. (*Journ. I.E.E.*, Feb., 1931, Vol. 69, pp. 299–314.)

The full paper, an *E.W. & W.E.* summary of which was dealt with in March Abstracts, p. 155. A long and interesting discussion follows (pp. 314–323) including a detailed reply by the author to points raised by Franklin, Green, Smith-Rose, Eckersley and others.

Über den Wirkungsgrad von Rundfunk-Sendeantennen (The [Ground Wave] Efficiency of Broadcasting Transmitting Aerials).—E. T. Glas. (*Zeitschr. f. hochf. Tech.*, Jan., 1931, Vol. 37, pp. 8–12.)

*Cf.* Feb. Abstracts, p. 97. The theoretical paper in *E.W. & W.E.* (Abstracts, same page) is here supplemented by the experimental results at the Karlsborg station, where vertical aerials I (actual height 52 m.), II (85 m.) and III (113 m.) were compared, all working on a wave of approximately 270 m. and a power in the aerial of 125 watts. Aerial I was worked as a quarter-wave aerial with added inductance; its static capacity was 430 cm. The higher aerial II (static capacity 870 cm., $\lambda_0 = 460$ m.) was tuned by a series condenser of 80 cm. capacity; the highest, III (cap. 955 cm., $\lambda_0 = 550$ m.) was worked with added inductance as a half-wave aerial.

A contour chart is given of the field strengths within about 2 kilometres of the station given by the 3 aerials, and the ground wave efficiency of each is worked out from the formula

$$\eta = 700 \cdot \frac{(Ed)^2}{P_a} \%.$$

The values of $\eta$ are respectively (I) 10.5, (II) 30.5, and (III) 34.5 %, *i.e.*, they are in the ratio 1 : 2.9 : 3.3. Theory, assuming a completely conductive earth, would give 1 : 2.1 : 2.4. The discrepancy—not found in the results in the Eckersleys-Kirke paper (1929 Abstracts, p. 329)—is attributed to the properties of the ground [the unsymmetrical distortion of the contour lines is attributed to the high metal masts].

The writer has, therefore, made use of the Reciprocity Reflection method (Ballantine, 1928 Abstracts, p. 341), but as the final formula is very complex he limits himself to the numerical working-out of two special cases, a quarter and a half-wave aerial with a ground of conductivity $5 \times 10^{-14}$ e.m.u. and dielectric constant 8. He gives the calculated vertical radiation diagrams of these aerials for wavelengths of 1,200, 400 and 40 metres, as compared with that for an infinite ground conductivity. These diagrams do not hold for the ground wave, but do hold for the space wave and therefore give useful information as to the ground-wave efficiency. They show the increasing superiority of the half-wave aerial as the wavelength gets shorter. This is confirmed by the fact that the Motala 1,348 m. wave gives a ground-wave efficiency of about 70 %, although the masts are only 120 m. high.

But the advantage of a high aerial lies not only in the decreased loss in space wave, but also in the possibility of reducing the losses in the earth lead and earth, thanks to the smaller current. This is another factor which gains importance as the wavelength decreases.

The writer then considers the various methods of coupling the high aerial to the transmitter circuit, their advantages and disadvantages. He continues by plotting the curve of ground-wave efficiencies, before-mentioned, against mast height (earth resistance at foot of aerial 13 ohms) and comparing this curve with the corresponding curve for zero resistance. The two curves converge as they bend over to nearly horizontal for a height of about 120 metres, from which he concludes that when an aerial has reached a height of about $\lambda/3$, its practical optimum height is attained—at any rate for the short broadcast waves and for aerial powers over 10 kw. Finally he confirms the close-up results by measurements at distances giving fields of 2 mv/m., namely, 14.7 km. for I, 17.8 and 19 km. for II and III. At 14.7 km., where I gave 2 mv/m., II and III gave this same value of field with powers in the aerial only $\frac{1}{2.3}$ and $\frac{1}{3}$ as great as that required by I.

Certain Factors Affecting the Gain of Directive Antennas.—G. C. Southworth. (*Bell Tech. Journ.*, Jan., 1931, Vol. 10, No. 1, pp. 63–95.)

*See* Jan. Abstracts, p. 41.

A Graphical Method for Determining the Magnitude and Phase of the Electric Field in the Neighbourhood of an Antenna carrying a Known Distribution of Current.—J. S. McPetrie. (*Journ. I.E.E.*, February, 1931, Vol. 69, pp. 290–298.)

The mathematical calculation of the field in the immediate neighbourhood of a transmitting aerial is somewhat laborious; this paper describes a graphical method of procedure by means of which calculations may be made for any desired arrangement of aerial. A simplified form of Hertz's equations (Wilmotte and McPetrie, 1928 Abstracts, p. 641) is used to give the field at a point on the ground due to a unit doublet at different heights in a vertical antenna two wavelengths long, and a number of curves are derived on the supposition that this doublet carries one ampère. It is explained how these curves may be applied with ease to find the field at various points and distances from an antenna having any given current distribution; or the field at various points in another parallel antenna.

The phase of the field is determined by the same method at various distances from different lengths of antenna, and a figure is given which shows that for distances greater than about $0.3\lambda$ there is a maximum difference of about 5 deg. between the phase of the field of a half-wave antenna and that due to the doublet at its base. This small difference explains why certain calculations based on the assumption that an antenna is small compared with the wavelength are approximately true when applied to antennae in which this assumption no longer holds.

The effect of the earth is taken into account in the last section, and it is shown how the same method may be used to find the field at any distance from an antenna when the dielectric constant and the conductivity of the earth are known.

Frame Aerial for Short or Ultra-short Waves.—(German Pat. 509616, Lorenz, pub. 10th Nov., 1930.)

To obtain good directivity, usually absent from loop or frame aerials when used for these waves, the inventor uses a frame with a length of side smaller than one-tenth of the wavelength, raised at least a half wavelength above the ground, and fed by concentric or screened parallel feeders.

Dual-Range Frame Aerial.—A. L. M. Sowerby and H. B. Dent. (*Wireless World*, 7th January, 1931, Vol. 28, pp. 12–14.)

Specially designed for the *Wireless World* band-pass superheterodyne receiver.

Safety Measures for Outdoor Antennae.—A. Halsted. (*Commercial Stds. Mthly.*, Jan., 1931, Vol. 7, p. 202.)

## VALVES AND THERMIONICS.

Theory of the Internal Action of Thermionic Systems at Moderately High Frequencies.—Part II.—W. E. Benham. (*Phil. Mag.*, Supp. No., Feb., 1931, Series 7, Vol. 11, No. 70, pp. 457–517.)

A sequel to the paper dealt with in 1928 Abstracts, p. 288. The theory outlined in Part I contained just sufficient analysis for the purposes of a "second order" solution and the extraction therefrom of an expression for the rectification effect as a function of the product $pT$ of the angular frequency $p$ and the time $T$ of transit of the electrons. Part II aims at an exhaustive analysis of the "first order" solution.

The thermionic system is replaced by an equivalent circuit, so far as its first order a.c. properties are concerned. "In general the equivalent circuit contains four components, but the circuit reduces to one having only two components in the particular case of two electrode systems. From the values of the 'equivalent circuit' components the admittance, conductance and susceptance of a parallel plane diode are evaluated as functions of $pT$. The conductance is negative at certain values of $pT$.

"Considerable space is devoted to the subject of the dielectric constant of space-charge, and experiments are quoted which support the theoretical conclusions. . . . The impedance of the equivalent circuit is always capacitative. The negative value of conductance at certain values of $pT$ is discussed in its bearing on the hypothesis that the negative-resistance property is inherent in the space-charge itself."

The diode theory contains an explanation of Barkhausen-Kurz oscillations and provides a lower limit for their angular frequency.

"A simple treatment neglecting space-charge confirms that there is no negative conductance in this case, showing that the negative conductance is a property resulting from the mutual repulsions of electrons. The frequency variation of the rectification effect with and without space-charge is discussed.

"An outline of the cylindrical case is given and a solution derived in the particular case $\frac{R}{a} \longrightarrow \infty$ . . . An approximate solution is obtained for finite values of $\frac{R}{a}$, which yields an expression for the dielectric constant of space charge between cylindrical electrodes."

Graphical Analysis of Output Tube Performance.—C. E. Kilgour. (*Proc. Inst. Rad. Eng.*, Jan., 1931, Vol. 19, pp. 42–50.)

The graphical method for the analysis of power valve output, based on laying down a load line on the family of static characteristics $I_a/E_a$ with $E_g$ as parameter, is first described and discussed in connection with a simple resistive load; it is pointed out that this procedure is often applied, erroneously, to the practical case where the plate load presents different resistances to a.c. and d.c. The writer shows that in this case the various load lines cannot be drawn through a common operating point, since the effective plate voltage shifts when rectification occurs. A suitable modification, however, renders the procedure applicable here.

The method is applied to an experimental pentode, and it is shown that in this case the condition for no rectification does not imply the absence of odd or even harmonics, though the latter will be of low value. The analysis also brings out the point that there is no definite ratio between optimum load resistance and internal valve resistance, but that this ratio will depend on the characteristics of the valve and on the working point assumed.

MESSUNGEN VON VOLTASPANNUNGEN ZWISCHEN REINEN METALLEN (Measurements of Volta Voltages [Potential Differences between Surfaces in a Dielectric and in Vacuo] between Pure Metals).—H. Kösters. (*Zeitschr. f. Phys.*, Vol. 66, No. 11/12, pp. 807–826.)

Good agreement is found between the Volta voltages of the metals measured and the differences in their electron work functions.

SOME PHOTOELECTRIC AND THERMIONIC PROPERTIES OF RHODIUM.—E. H. Dixon. (*Phys. Review*, 1st. Jan., 1931, Series 2, Vol. 37, pp. 60–69.)

PHOTOELECTRIC PROPERTIES OF OXIDE CATHODES.—Huxford. (*See* under " Phototelegraphy.")

THERMAL FLUCTUATIONS OF THE SURFACE POTENTIAL OF A CATHODE AS AFFECTING ELECTRON EMISSION.—K. H. Kingdon. (*Phys. Review*, 1st Jan., 1931, Series 2, Vol. 37, No. 1, pp. 89–90.)

DER VERLAUF DER AKTIVIERUNG VON THORIERTEM WOLFRAM UND THORIERTEM MOLYBDÄN (The Course of the Activating Process in Thoriated Tungsten and Thoriated Molybdenum).—A. Gehrts. (*Zeitschr. f. tech. Phys.*, February, 1931, Vol. 12, pp. 66–71.)

In order to reconcile experimental results with theory, Langmuir introduced the idea of " induced vaporisation," depending not only on the condition of the surface but also on the diffusion velocity of the thorium atoms at the surface ; he imagined that the vaporisation of thorium atoms by the subjacent tungsten atoms was indeed small at the activating temperature, but that this was not the case as regards the vaporisation by other thorium atoms : wherever a thorium atom, by diffusion, reached the surface at a spot occupied by another thorium atom, the latter was vaporised.

Clausing's researches, however, lead to the conclusion that the diffusion of the thorium atoms can take place *not* through the tungsten crystal lattice but only between the individual crystallites.

The present paper shows that by making certain assumptions the experimental and theoretical results can be reconciled without introducing any idea of "induced vaporisation," by the use of Clausing's picture of the migration of the thorium as a sliding-along the crystal surfaces of separation instead of a diffusion through the crystal lattices. It is also possible to explain the effect of the thorium oxide addition in tungsten filaments, in decreasing the apparent grain size, by the adsorption and migration of reduced thorium along the boundary surfaces of the crystals.

NEW STRUCTURE PRINCIPLE IN TUBE DESIGN.—W. L. Krahl [Arcturus Company]. (*Rad. Engineering*, Jan., 1931, Vol. 11, pp. 36 and 46.)

A description of the " unitary " structure, illustrated by the new Arcturus Type 127 detector and amplifier valve. The unitary structure principle consists in assembling the electrodes as a rigid unit in which they are interdependent and cannot move with relation to one another. All electrodes, in such a valve, are supported at both ends by mica yokes in planes perpendicular to the axis of the electrodes. In this particular valve the cylindrical anode is ribbed to increase its sturdiness ; the yokes are supplemented by a cathode collar and grid clip, both accurate die-made parts which reinforce the unit and serve as electrical connections. The whole unit, assembled without any adjustment, is slipped over the stem wires and spot-welded to them.

INTERESTING VALVE DEVELOPMENT.—W. I. G. Page. (*Wireless World*, 17th December, 1930, Vol. 27, pp. 678–680.)

Experiments with a special screen-grid valve of low impedance having a third grid to allow high screen voltages without secondary emission effects, specially constructed for the *Wireless World*. In addition to interesting results in aperiodic r.f. amplification and detection, it appears that one of the most important uses of such a valve is in a tuned r.f. stage where the chances of cross-modulation are very considerably reduced owing to the large available grid swing. The author points out the need for a low impedance valve with negligible input impedance.

PENTODE *versus* TRIODE.—A. L. M. Sowerby. (*Wireless World*, 26th November, 1930, Vol. 27, pp. 592–595.)

Conditions for distortionless reproduction with both types of valve are examined and attention is given to the design of compensating devices for pentodes when moving-iron speakers are employed. Figures of merit are put forward for output valves, in which sensitivity is expressed in terms of milliwatts undistorted output per volt grid swing. It is shown that the pentode, if used with a suitable speaker and with a suitable output circuit, can give a better frequency response curve than the triode.

NEW MAGNETRON VALVE FOR ULTRA-SHORT WAVE GENERATION.—J. Liston. (*Gen. Elec. Review*, Jan., 1931, Vol. 34, p. 57.)

In an article on " Developments in the Electrical Industry during 1930," a new magnetron is referred to, having two anodes and a cathode, and giving " useful amounts of power " at frequencies up to 400 megacycles/sec. [about 10 w. output at this frequency]. A larger water-cooled type was also designed which gave an output of about 1 kw. at 100 megacycles/sec.

## DIRECTIONAL WIRELESS.

UN RADIOGONIOMÈTRE ENREGISTREUR. SON APPLICATION AUX PARASITES ATMOSPHÉRIQUES (A Recording Radiogoniometer. Its Application to Atmospherics).—R. Bureau. (*Comptes Rendus*, 19th Jan., 1931, Vol. 192, pp. 170–172.)

A modification of Ranzi's neon-lamp photographic recorder, to make this register not only the variations in number and strength of the atmospherics but also their direction. A gramophone motor drives a frame aerial whose vertical axis carries a cylinder with a spiral slot. If this moving slot is interposed, in addition to the usual fixed slot, between lamp and photographic paper, the height of the record on the paper indicates the azimuth of the frame. The neon lamp may be inside the cylinder and the paper outside, unrolling continuously past the two slots : or the lamp may be outside and the paper, on a clockwork-driven drum, inside the cylinder [the records given were taken by the latter method]. The lamp may be connected, as in Ranzi's apparatus, across the secondary of a transformer ; or it may be controlled by a Baudot relay—this latter method being particularly good for weak atmospherics, and also providing a means of isolating those which are above a certain energy level.

As is obvious, the apparatus is applicable to the study of the variations of apparent direction of a station.

Flugsicherung durch Richtfunkbaken (Radio-beacon Aids to Aerial Navigation).— –. Rahskopff. (*Zeitschr. V.D.I.*, 24th Jan., 1931, Vol. 75, pp. 116–117.)

Based chiefly on the U.S.A. system, and including a chart of the network there at the middle of 1930.

## ACOUSTICS AND AUDIO-FREQUENCIES.

Die verzerrungsfreie Leistungsübertragung auf einen Lautsprecher durch den Ausgangstransformator (The Distortionless Transfer of Power to a Loud Speaker through the Output Transformer).—H. Wigge. (*Zeitschr. f. hochf. Tech.*, Jan., 1931, Vol. 37, pp. 16–17.)

The transfer of power by an output transformer is dependent on frequency. There is one frequency for which the transferred power is a maximum. This maximum power depends on the breadth of the frequency band which has to be transferred without distortion : the power decreases with this breadth, according to equation (25) :—

$$P = \frac{E_g^2}{2D^2} \cdot \frac{M^2 R_L}{L_a^2 L_2^2 \sigma^2} \cdot \frac{1}{b^2 + \omega^2\left(1 - \frac{\omega^2_{\text{max.}}}{\omega^2}\right)^2},$$

where $E_g$ is the a.c. potential applied to the grid of the output valve, $D$ the "durchgriff" of the latter, $M$ the mutual inductance between primary and secondary of the output transformer, $L_a$ the inductance of the primary, $L_2$ that of the secondary increased by the loud speaker inductance, $R_L$ the effective resistance of the loud speaker,

$$\sigma = 1 - \frac{M^2}{L_a L_2},$$

$b$ is the breadth of the undistorted band, $\omega$ the angular frequency at which the power $P$ is transferred, and $\omega_{\text{max.}}$ the angular frequency at which the power transferred is a maximum. Equations (23) and (24, *a* and *b*) give $\omega_{\text{max.}}$ ; if $b$ is taken as 10,000, with a lower limit of 30, the frequency $f_{\text{max.}}$ comes out at 550 cycles/sec.

The condition for optimum matching of the output stage is given by $\frac{R_i + R_a}{L_a} = \frac{R_2 + R_L}{L_2}$, where $R_i$ is the internal resistance of the valve, and $R_a$ and $R_2$ the resistances of the transformer primary and secondary. Equation (29) gives the maximum power which can be transferred ; if $R_a \ll R_i$ a simplified formula (30) gives

$$P_{\text{max.}} = \frac{E_g^2}{8} \cdot \frac{S}{D} \cdot k^2,$$

representing the most favourable value obtainable by matching. The various formulae yield all the data for the design of the transformer.

Loud Speaker Impedance.—W. A. Barclay. (*Wireless World*, 3rd and 10th Dec., 1930, Vol. 27, pp. 627–630 and 662–666.)

Recognising the value of appropriate "matching" between the receiver set and loud speaker, the author provides a four-line variable alignment chart from which numerical values of resistance, inductance, impedance and frequency can be read.

Graphical Analysis of Output Tube Performance.—Kilgour. (*See* under "Valves and Thermionics".)

Eine Methode zur Untersuchung der Schwingungen von Membranen, im besonderen von Lautsprechermembranen (A Method of Investigating the Vibrations of Diaphragms, particularly Loud Speaker Diaphragms).—B. Voigt : V. Engelhardt. (*Zeitschr. f. tech. Phys.*, Feb., 1931, Vol. 12, pp. 76–85.)

An application of Töpler's stroboscopic method for vibrating strings to the study of diaphragm vibration (*cf.* von Ardenne, March Abstracts, p. 159). The apparatus and procedure are dealt with in detail, and the results with a diaphragm of special design (the "Sectorphone" diaphragm—see 1930 Abstracts, p. 400) are discussed. The method is competent to deal with complex modes of vibration : the individual components can be separated out.

Modern Views on the Moving Coil Loud Speaker.—N. W. McLachlan. (*Wireless World*, 21st and 28th January, 1931, Vol. 28, pp. 52–54 and 100–102.)

An Efficient Loud Speaker at the Higher Audible Frequencies.—L. G. Bostwick. (*Journ. Acoust. Soc. Am.*, Oct., 1930, Vol. 2, pp. 242–250.)

"A description of a loud speaker designed for use as an adjunct to existing types to permit efficient radiation at the higher audible frequencies."

Über die akustische Strahlung von Membranen (On the Acoustic Radiation from Membranes [Application to Loud Speaker Theory]).—H. Stenzel. (*Ann. der Phys.*, Series 5, 1930, Vol. 7, No. 8, pp. 947–982.)

Author's summary :—General formulae for the directivity and radiation factors [of a membrane] are deduced from Rayleigh's formula for the velocity-potential. In contrast to the cases hitherto discussed in the literature of the subject, which are limited to those of membranes moving as a rigid body, an investigation is given of membranes in which the velocity decreases to zero on approaching the boundary, as is the case with a membrane stretched on a frame.

The manner in which the radiation resistance depends on the frequency is of considerable practical importance, particularly when loud-speaker membranes are under discussion. Formulae are derived for the cases of a rectangle and an ellipse which correspond to those derived by Rayleigh for a rigidly moving circular disc. In both cases the resulting infinite series are not well suited for practical calculation. In the case of the rectangle this difficulty is overcome by the use of auxiliary functions closely related to the integral sine. For the ellipse practical examples are calculated by partial integration, combined with graphical methods. In the same way it is possible to give a graphical representation of the mode of dependence on distance apart, and on frequency, of the radiation resistance of two circular rigid discs.

Finally, a general type of membrane, the rigid space membrane, is defined; this should be considered because of its connection with modern loud speaker development. It is shown that the calculation can be performed for a definite class of such types, using the method of images. It is then possible to calculate the conical membrane approximately. The results obtained agree well with practical measurements.

### SOME MEASUREMENTS OF A LOUD SPEAKER IN VACUO.—P. K. Turner. (*Electrician*, 6th Feb., 1931, Vol. 106, p. 210.)

Short summary of a paper read before the I.E.E. (Wireless Section). The procedure used is to measure the electrical impedance of a moving-coil loud speaker (*a*) with coil held fast, (*b*) with coil free but *in vacuo*, and (*c*) under normal conditions. The measuring equipment is described and the results given of a series of measurements between 40 and 6,000 cycles/sec. From these, the characteristics of the instrument are derived. The results yield some indication as to why loud speakers of this type give a much better performance at high frequencies than would be expected from simple theory: the inductance of the coil and the mass of the diaphragm, both of which cut down the output at high frequencies, are shown to fall off rapidly as the frequency rises, while the acoustic resistance does not fall off to the same extent and is, in fact, much in excess of the theoretical radiation resistance.

### NOTE SUR LA VITESSE DU SON DANS LE PAPIER (Note on the Velocity of Sound in Paper).—M. Caplet. (*Assoc. franç. p. l'Av. des Sci.*, 53rd Session, pp. 242–244.)

The writer's measurements on a sample of drawing paper of density 1.070 give a velocity for longitudinal propagation of 2,300 metres/sec., for transverse propagation 1,450 metres/sec. "In the theory of vibrational movement, it is assumed that the pulsating piston is infinitely rigid and moves as a whole. The velocity of propagation found above shows that this hypothesis is fragile." If a disc is driven from its centre and has maximum amplitude there and zero amplitude at its edge, the radius will represent a quarter wavelength: thus a disc 30 cm. in diameter will correspond to a frequency of 2,500 p.p.s. He admits that in practice things are not so simple: it has recently been shown on a Western loud speaker of 40 cm. diameter that even at 350 p.p.s. circular nodes were formed. He sums up by saying that to obtain correct reproduction the membrane should be of small diameter and very rigid.

### NOTE SUR LES BOBINAGES DE HAUT-PARLEURS (Note on Loud Speaker Windings).—M. Caplet. (*Assoc. franç. p. l'Av. des Sci.*, 53rd Session, pp. 244–247.)

The writer concludes that as a general rule the number of turns employed is too great, leading to considerable distortion at the higher frequencies. He considers that 500 to 1,500 turns, according to the valve used, are sufficient to satisfy the conditions of intensity of sound and absence of distortion. Where there are two bobbins, it is often better to connect in parallel rather than in series.

### CONDENSER AND CARBON MICROPHONES—THEIR CONSTRUCTION AND USE.—W. C. Jones. (*Bell Tech. Journ.*, Jan., 1931, Vol. 10, No. 1, pp. 46–62.)

The two microphones used extensively in sound-recording for motion pictures are the condenser microphone and the carbon microphone. This paper reviews the construction of these instruments and considers some of their transmission characteristics and the precautions which should be exercised in their use.

In the case of the condenser microphone, the factors in design and construction contributing to increase in sensitivity and stability are described. Certain discrepancies exist between the conditions under which the thermophone calibration of the condenser microphone is made and those in the studio. The nature of these discrepancies and their bearing on the use of the microphone are discussed.

A description is also given of the outstanding design features of the push-pull carbon microphone, and suggestions are made as to the precautions necessary to obtain the best quality, maximum life, etc.

### MICROPHONIC ACTION IN TELEPHONE TRANSMITTERS.—F. S. Goucher. (*Science*, 7th Nov., 1930, New Series, Vol. 72, pp. 467–470.)

"A discussion of the theories of microphonic action and description of the results of some experiments on granular carbon used in telephone transmitters." See also 1930 Abstracts, pp. 574 and 634.

### RATING THE TRANSMISSION PERFORMANCE OF TELEPHONE CIRCUITS.—W. H. Martin. (*Bell Tech. Journ.*, Jan., 1931, Vol. 10, No. 1, pp. 116–131.)

### THE DETERMINATION OF THE ACOUSTICAL CHARACTERISTICS OF SINGLY-RESONANT HOT-WIRE MICROPHONES.—E. T. Paris. (*Proc. Physical Soc.*, 1st Jan., 1931, Vol. 43, Part 1, pp. 72–86.)

Author's abstract:—A method is described for measuring the damping-coefficients and conductances of the orifices of the small resonators used in the construction of hot-wire microphones. Observations show that resonant microphones with cylindrical necks of diameter between 0.5 and 0.64 cm. and length between 1.2 and 2.25 cm. have damping-coefficients which are about 23 % greater than the values indicated by theory. The observed conductances of the necks agree very closely with those calculated from a formula in which allowance is made for the added inertia due to viscosity.

Absolute Calibration of Condenser Transmitters.—L. J. Sivian. (*Bell Tech. Journ.*, Jan., 1931, Vol. 10, No. 1, pp. 96–115.)

Mesures des Intensités sonores (The Measurement of Sound Intensities: the Acoustic Comparator).—F. Canac. (*Assoc. franç. p. l'Av. des Sci.*, 53rd Session, pp. 239–242.)

This non-electrical device consists of a piston resonator with a hollow piston rod in which slides an "exploring" tube leading by rubber tubing to the ear. The piston is adjusted to resonance with the exploring tube pulled out; then by adjusting the exploring tube so that its end moves between a node and an antinode, a complete range of intensity is obtained: in this way it is possible to measure the wavelength and the width of the threshold of audition, and from these the physiological intensity of the sound can be calculated.

Problems in Acoustic Interferometry with Gases.—J. C. Hubbard. (*Phys. Review*, 1st Dec., 1930, Series 2, Vol. 36, No. 11, pp. 1668–1669; also letter from H. W. Pielemeier, p. 1667.)

Supersonic Interferometers.—E. Klein and W. D. Hershberger. (*Phys. Review*, 1st Jan., 1931, Series 2, Vol. 37, No. 1, p. 109.)

Abstract only.

Sound Absorption Determined by Transmission Measurements.—F. R. Watson, (*Phys. Review*, 1st Jan., 1931, Series 2. Vol. 37, No. 1, p. 109.)

Abstract only.

Rayleighsche Scheibe als ballistisches Gerät (The Rayleigh Disc as a Ballistic Instrument).—L. Freimann and I. Russakoff. (*Zeitschr. f. tech. Phys.*, Feb., 1931, Vol. 12, pp. 125–126.)

The Rayleigh disc can be applied to the measurement of sound impulses just as well as to the measurement of continuous sounds. The ballistic constant of the instrument is shown to depend only on the properties of the disc and the nature of the medium, so that the measurements are of an absolute character. The results arrived at from theory are confirmed by tests on the output of a loud speaker excited by the breaking of a direct current. Beloff's measurements (1930 Abstracts, p. 281) suggest a quadratic dependence of the disc displacement on the current strength, but this is not found to be exactly correct.

The Formation of Striae in a Kundt's Tube.—R. V. Cook. (*Science*, 24th Oct., 1930, Vol. 62, pp. 422–423.)

Some Effects of Intense Audio-Frequency Sound.—N. Gaines. (*Phys. Review*, 1st Jan., 1931, Series 2, Vol. 37, No. 1, p. 109.)

Abstract only.

Les Instruments de Musique radio-électriques: les Appareils Theremin et Martenot (Radio-electric Musical Instruments: the Theremin and Martenot Equipments).—J. Dumas. (*Génie Civil*, 7th Feb., 1931, Vol. 98, pp. 137–139.)

Neon Musical Oscillator.—R. Raven Hart. (*Wireless World*, 10th December, 1930, Vol. 27, pp. 648–650.)

An article on Trautwein's instrument ("Trautonium") referred to in 1930 Abstracts, p. 575; and on his theory of tone quality on which it is based—the "Hallformanten" (here rendered "tone-formers") theory dealt with in Feb. Abstracts, p. 101.

Talking Films: The R.C.A. Photophone System.—W. H. O. Sweeney. (*Wireless World*, 28th January, 1931, Vol. 28, pp. 82–85.)

Der Wiedergabespalt als Fehlerquelle bei Lichttonfilmen (The Slot as a Source of Error in the Reproduction of Sound-on-Film Records).—H. Frieser and W. Pistor. (*Zeitschr. f. tech. Phys.*, February, 1931, Vol. 12, pp. 116–121.)

However much a wide slot may be desired for the sake of the additional illumination, the width has to be kept down to some 20–30 $\mu$ to avoid the undue weakening of the higher frequencies. A slanting slot, either in recording or reproducing, in the intensity process causes only linear distortion, whereas in the amplitude process it causes but little of this, non-linear distortion being predominant in this case. The calculations show that the correct adjustment of the slot, and the accurate leading of the film past it, are of the greatest importance—particularly for the amplitude process.

A failure of uniformity in the illumination of the slot causes distortion only in the amplitude process, and even here the calculations show the distortion is only slight for the lack of uniformity met with in practice.

Demonstrations of Hoovenaire Giant Sound Amplifiers.—(*Rad. Engineering*, Jan., 1931, Vol. 11, p. 33.)

"For ten hours Christmas carols were broadcast over an area of approximately nine square miles" (from the 81st floor of the Empire State Building in New York).

The Design and Construction of Broadcast Studios.—O. B. Hanson and R. M. Morris. (*Proc. Inst. Rad. Eng.*, Jan., 1931, Vol. 19, pp. 17–34.)

L'Isolement phonique et l'Acoustique des Salles de Cinéma sonore (The Sound Installation and Acoustics of Sound Cinema Halls).—I. Katel. (*Génie Civil*, 14th Feb., 1931, Vol. 98, pp. 164–166.)

## PHOTOTELEGRAPHY AND TELEVISION.

A New Television System.—(*Wireless World*, 14th January, 1931, Vol. 28, pp. 38–39.)

A description of the television apparatus demonstrated for the first time by the Gramophone Co., Ltd., at the Exhibition of the Physical and Optical Societies.

The standard of definition in the projected image which the H.M.V. engineers have set for themselves requires a frequency range in the amplifiers from 20 to 20,000 cycles. Such an amplifier has been produced with a deviation of not more than 2 decibels over this range. The experiments have also resulted in a distinct advance in the technique of construction of photoelectric and Kerr cells.

To provide a picture definitely comparable with that of the cinema, the image, which is projected on a ground glass screen 24in. × 20in., is divided into 15,000 elements. Standard size cinematograph films taken at the minimum speed of 12½ pictures per second are used. These are scanned by a revolving lens drum, and the light is passed over five equidistant photoelectric cell apertures which divide the light simultaneously into five vertical sections.

The amplifiers are divided into two banks each containing two stages per section. There are five channels of communication between transmitter and receiver, and a sixth channel for synchronisation, which is carried out by coupling a 1,200-cycle generator of the phonic wheel type, mounted on the lens drum spindle of the transmitter, to a motor of similar design on the receiver mirror drum.

The output from the receiver amplifiers is impressed on a bank of five Kerr cells complete with crossed Nicol prisms which modulate the light from a powerful arc lamp.

At present armoured cables are used to link the transmitter and receiver, and radio communication has not so far been attempted.

A Multi-Channel Television Apparatus.—H. E. Ives. (*Bell Tech. Journ.*, Jan., 1931, Vol. 10, pp. 33–45; *Journ. Opt. Soc. Am.*, Jan., 1931, Vol. 21, pp. 8–19.)

The television enthusiast, when he predicts carrying the stage and motion picture screen into the home over electrical communication channels, has at the back of his mind the kind of detail presented by an electrically transmitted photograph, in which the number of elements is perhaps 350,000. Already, all parts of the television system are having serious difficulty in handling the 4,500-element image: *e.g.*, the neon lamp used in the two-way television referred to in previous abstracts had to be assisted by a frequently renewed admixture of hydrogen. A discussion on these lines leads on to a description of a three-channel apparatus giving a 13,000-element image [*cf.* H.M.V. System, above]. The multi-scanning apparatus uses a scanning disc over whose holes are placed prisms of several different angles, and this plan is also used at the receiver. When motion picture film is employed, the transmitting disc scanning holes are in a *circle* instead of a spiral, the longitudinal scanning of the film being produced by giving the latter a continuous uniform motion at right angles to the motion of the scanning holes. The continuous motion of the film avoids the loss of transmission time which an intermittent motion demands for the shutter interval.

The writer considers that even the improved results given by this 13,500-element system indicate that an enormously greater number of elements is required for general news or entertainment purposes. Even this three-channel system presents one serious practical difficulty—that of keeping the three channels properly related to each other in signal strength in spite of sudden changes such as that from a close-up to a wide angle view: the eye is quite sensitive to the irregularity arising from one channel giving too strong or too weak signals.

L'Émission en Télévision (Television Transmission).—R. Barthelémy. (*L'Onde Élec.*, January, 1931, Vol. 10, pp. 5–35.)

(1) Direct scanning methods, from Sawyer's 1877 project of a lens in a pivoted oscillating tube with rapid up-and-down and slow right-to-left movements, through Leblanc's oscillating mirror to the Nipkow disc with holes, Brillouin's disc with lenses, Rosing's rotating mirror-polyhedra (followed by Weiller's form of the same idea, and developed later by Karolus).

(2) Beam scanning methods, originated by Ekström with his oscillating mirror (like Leblanc's scanning mirror) utilised by Mihaly; modified by Belin and Holweck (also Dauvilliers) with their two oscillating mirrors; replaced, by Jenkins, by his lens-and-prisms disc, and by Baird by his disc and lenses or his two parallel discs, of equal speed, one producing a moving luminous spot on a translucent screen, the other scanning this spot and handing it on to the subject at twice the speed of either disc. Finally, Baird's method in which the beam transmitted by one lens of his disc is collected, after reflection, by the succeeding lens and concentrated on the photoelectric cell; his infra-red scheme; Alexanderson's simultaneous scanning of several parts (*cf.* two preceding abstracts); and cathode-ray methods (Campbell Swinton, Schoultz).

(3) Photoelectric cells. After mentioning Leblanc's idea of using the pressure of light to move a magnetic surface, and dismissing the selenium cell on account of its lag, the writer compares vacuum and gas-filled photoelectric cells and refers to the great utility, for comparing sensitivities, of the electrometer developed by Grassot, the inventor of the Fluxmeter; it has, for a stable régime, practically infinite resistance, and it gives a 10 cm. pointer-movement for 100 volts.

(4) This long section deals with the coupling of the cell to the amplifier, and with the amplifier itself. The writer finds that the former problem has by no means been solved satisfactorily by some foreign workers. He considers at length the influence of the static inter-electrode capacities,

increased by the dynamic capacities when the valve is in action, on what—in telephony—is called "attack." To avoid having to reduce the working resistance and thus the amplification, the use of the screen-grid valve is necessary. Regarding the coupling of the amplifier stages, he mentions the tendency to employ an auxiliary modulation of the light beam, which he considers as presenting no difficulties at the transmitting end (where extra complications do not matter) but as demanding a simple solution at the receiving end: his own method (which will be shown at his second lecture, when his new system will be demonstrated) consists in producing a very short interruption of the current at the end of each line.

(5) The modulation of the carrier wave: propagation: echoes: parasites. The modulated wave must not be amplified before emission: the modulation must occur on the amplified wave, otherwise the upper frequencies will be cut down by the successive stages of amplification. The choice of wavelengths—depending on the required detail. Echoes:—a path difference of 17 km. is enough to cause a visible disturbance. Parasites:—the writer is more optimistic about these than about echoes, in view of the fact that the Verdan principle of the superposition of several transmissions, so useful in telegraphy, is an essential part of television.

Television in Colour from Motion Picture Film.—H. E. Ives. (*Journ. Opt. Soc. Am.*, Jan., 1931, Vol. 21, pp. 2–7.)

After outlining how the problem can be solved with film in which the colours are incorporated by dyes (*e.g.*, the Technicolor system) by means of the Bell Laboratories' three-colour transmitting and receiving system (1930 Abstracts, p. 220) the writer says that if television from film should become popular, the chief demand will probably be for *cheap* films which would be shown *within a few hours at most* of the event; such a film is provided by the Kodacolor process, using an image which is black and white but distributed in a triple linear mosaic by lenticular ridges on the film. He then outlines two alternative television scanning arrangements for use with such films.

Some Optical Features in Two-Way Television.—H. E. Ives. (*Journ. Opt. Soc. Am.*, Feb., 1931, Vol. 21, pp. 101–108.)

Improvements in the optical features of the two-way television system (Jan. Abstracts, p. 47, and 1930 Abstracts, pp. 401, 402 and 577). The blue scanning beam upset the proper balance of tone values in the face scanned: this defect is now avoided by using a purple beam and adding a group of red-sensitive (caesium oxide) cells to the blue-sensitive potassium cells. In making this change, motion-picture projection incandescent lamps were introduced in place of arc lamps, and other alterations made. In the old receiving system, the heavy current in the neon lamp, necessary to give the required brightness, caused rapid sputtering and the need for frequent renewals: by the introduction of a condensing lens associated with each disc-hole, and a fixed collimating lens, the lamp cathode may be made quite small and may be removed to a considerable distance from the glass wall; the results are a very high current density obtainable for a relatively small expenditure of energy, and a long life for the lamp.

Eine trägheitsschwache Selenzelle (A Selenium Cell with Small Lag [Thirring Cell]).—F. Noack. (*Rad., B., F. f. Alle*, No. 2, Vol. 10, 1931, pp. 84–85.)

A short article on the cell referred to in 1930 Abstracts, p. 512 (Petsch). At its maximum voltage of 30 v. its maximum sensitivity is about 40,000 microampères per lumen (about a thousand times as great as that of an average photoelectric cell). This is for static conditions: for periodic illumination the sensitivity decreases "somewhat," and more and more as the frequency increases. But by connecting the cell in the manner shown, the grid condenser and the two high ohmic resistances (one on either side of the condenser) give a compensating effect, and by combining this with compensation at the other end (*e.g.*, at the receiver in television or optical telephony) the results are at least as free from inertia effects as those given by the more expensive photoelectric cell; while the higher sensitivity is equivalent to at least two stages of amplification. The construction of the cell is outlined.

Cellules photoélectriques aux Métaux alcalins sur Support de Magnésium (Photoelectric Cells employing Alkali Metals on a Base of Magnesium).—G. Déjardin. (*Journ. de Phys. et le Rad.*, No. 5, Vol. 1, Series 7, pp. 66–67.)

Description of a process for the rapid manufacture of a sensitive and stable cell by depositing a very fine coating of the alkali metal on a magnesium layer obtained by vaporisation in a vacuum.

The Case Thalofide Photoelectric Cell.—P. A. Tchoodakov. (*Westnik Elektrot.*, No. 3, 1930, pp. 52–64.)

In Russian. The results of numerous tests are given. The sensitivity is good for waves between 0.546 and 1.2$\mu$, being greatest at about 1.0$\mu$.

Photoelectric Properties of Oxide Cathodes.—W. S. Huxford. (*Phys. Review*, 1st Jan., 1931, Series 2, Vol. 37, No. 1, p. 102.)

Abstract only. "The effect of applied fields on the photoelectric work function of barium-strontium oxide cathodes has been investigated in the light of recent theories on electron emission from adsorbed metallic films. . . . A striking dependence of the photoelectric work function upon the applied fields has been found."

Photoelectric Work Function and its Dependence on the Applied Field.—Huxford.

(*See* above.)

Photozellen in Wissenschaft und Technik (Photoelectric Cells in Science and Technics).—B. Lange. (*Naturwiss.*, 30th Jan. and 6th Feb., 1931, Vol. 19, Nos. 5 and 6, pp. 103–107 and 128–132.)

A general account of the development of photoelectric cells from their first discovery to the present time, and of their application to photometric measurements and television. Special attention is given to the cell invented by the author (*cf.* Feb. Abstracts, p. 104).

The Manufacture of Photoelectric Cells.—G. Déjardin. (*Revue d'Optique*, Sept., 1930, Vol. 9, pp. 337–352.)

Modern methods of manufacture: increasing the sensitivity to the longer waves: results with cathodes of molecular thickness.

Some Photoelectric and Thermionic Properties of Rhodium.—E. H. Dixon. (*Phys. Review*, 1st Jan., 1931, Series 2, Vol. 37, No. 1, pp. 60–69.)

Photoelectric Emission from Thin Films of Caesium.—L. R. Koller. (*Phys. Review*, 1st Dec., 1930, Series 2, Vol. 36, No. 11, pp. 1639–1647.)

Zur Quantenmechanik photoelektrischen Prozesse (The Quantum Mechanics of Photoelectric Processes).—M. Stobbe. (*Ann. der Phys.*, 1930, Ser. 5, Vol. 7, No. 6, pp. 661–715.)

Recent Developments in Photoelectricity.—C. E. Mendenhall. (*Science*, 30th Jan., 1931, Vol. 73, pp. 107–113.)

Address to the American Association for the Advancement of Science.

Über die Wirking adsorbierter Gasschichten auf den Photoeffekt der Salze (On the Effect of Adsorbed Gas Layers on the Photoelectric Effect of Salts).—J. Klaphecke. (*Naturwiss.*, 23rd Jan., 1931, Vol. 19, No. 4, p. 87.)

The Photoelectric Absorption of Gamma Rays.—L. H. Gray. (*Proc. Camb. Phil. Soc.*, Jan., 1931, Vol. 27, Part 1, pp. 103–112.)

## MEASUREMENTS AND STANDARDS.

A Method for Measuring the Amplitude and Frequency of Vibration of Bodies which may be heated to Incandescence.—W. E. Meserve. (*Review Scient. Instr.*, Jan., 1931, Vol. 2, pp. 47–48.)

Light from the vibrating body is focused on an optical wedge—two prisms of the same index of refraction, *one clear glass and the other yellow*, placed together so as to form a rectangular bar. After passing through this compound wedge, the light falls on a photoelectric cell, whose output after amplification is impressed on a stabilised c.-r. oscillograph with linear time base [Bedell and Reich "oscilloscope"—1930 Abstracts, p. 581].

Accurate Method of Measuring Transmitted Wave Frequencies at 5,000 and 20,000 Kilocycles per Second.—E. L. Hall. (*Proc. Inst. Rad. Eng.*, Jan., 1931, Vol. 19, pp. 35–41.)

*See* January Abstracts, p. 49.

Sur la Comparaison à Distance de la Fréquence des Diapasons (The Comparison at a Distance of the Frequency of Tuning Forks).—R. Jouaust and B. Decaux. (*Comptes Rendus*, 26th Jan., 1931, Vol. 192, pp. 218–219.)

The transmission from the Eiffel Tower was modulated by the tuning fork of the National Laboratory of Radioelectricity, and the pitch was measured by the National Physical Laboratory (Teddington) and by the Naval Academy (Livorno), as well as by the French laboratory, each laboratory using its customary methods. Although the measurements only took about half an hour, the results agreed within a few parts in a million.

Improvements in Piezo Crystals in Gas-filled Containers (German Pat. 506356, Telefunken, pub. 4th Sept., 1930.)

Crystals in neon or neon-helium have the disadvantage that their natural frequencies slowly change with the passage of time: this is attributed to metallic sputtering of the electrodes, and according to the present invention is prevented by the addition of a small percentage of hydrogen or of argon, krypton and xenon.

Investigation of Piezo-quartz Oscillator.—S. N. Kakurin. (*Westnik Elektrot.*, Nos. 4 and 5, 1930, pp. 151–157 and 173–179.)

In Russian. Analysis of equivalent circuit: derivation of general equation for oscillating condition: a particular case of oscillation: relation between dimensions of quartz plate and constants of equivalent circuit: stable state of piezo-electric oscillator: two modes of work in grid circuit: experimental proof.

The Frequency Stability of Piezo-Electric Monitors.—J. K. Clapp. (*Gen. Radio Exper.*, Nov., 1930, Vol. 5, pp. 1–4.)

Curves and data are given for the frequency variations (in the broadcast band) for changes in temperature, in tuning, in plate and filament voltages, changes in the valve itself, and vibration. Under average operating conditions, the sum of all these changes, if they happen to be all in the same direction, may be expected to amount to ± 12 parts in a million.

Dégagement d'Électricité dans les Cristaux de Quartz par Flexion (The Setting Free of Electricity in Quartz Crystals by Flexion).—E. P. Tawil. (*Comptes Rendus*, 2nd Feb., 1931, Vol. 192, pp. 274–277.)

In a former Note (1929 Abstracts, p. 159) on the disengagement of electricity from quartz crystals by *torsion*, the writer mentioned other modes of disengagement, due to flexion. He has hesitated to publish his results because they seemed to be in contradiction to the conditions of symmetry of the crystal, and to the laws of piezoelectricity. However, he now publishes them in the hope that by keeping strictly to the facts and avoiding hasty conclusions our knowledge of the mechanical properties of quartz may usefully be increased.

The deformation produced by a given effort depends not only on the direction in which the fragment of crystal has been cut from the mother crystal, but also on its geometrical form. Nevertheless his experiments showed identical results whether plates or rods of rectangular or circular section were employed: he therefore used the cylindrical form because it allowed a continuous exploration round the axis. Three cylinders were made, with their axes (*a*) parallel to the optical axis, (*b*) parallel to a binary axis and (*c*) normal to the optical axis and to a binary axis. One end was fixed, and the pressure was applied at the other end normally to the axis.

The following results are given for these three cases:—(*a*) Whatever the orientation of the plane of flexion, electricity is set free on the envelope, positive on one half, negative on the other, the two zones being separated by a plane of zero disengagement which passes always through the axis and through the direction of the force. (*b*) When the force is normal to the ternary axis, the separating plane passes through the cylinder axis (binary axis) and the optical axis. If the plane of flexion is differently oriented, the separating plane also changes its orientation, but not according to a proportional law (a curve is given showing this). (*c*) Whatever the plane of flexion, the charges divide the envelope into 4 zones alternately positive and negative. There are two planes of zero disengagement, each passing through the cylinder axis and the bisectrix of the angle between the ternary axis and the direction of the force. They are not strictly at right angles, however; the writer has found displacements of several degrees without being able to determine whether these are due to errors.

In all three cases, the polarities reverse directly the effort is decreased or its direction reversed.

MAGNETOSTRICTIVE OSCILLATOR.—(German Pat. 505906, Elektroswias, Leningrad, pub. 27th Aug., 1930.)

Retroaction is provided by mechanically connecting the magnetostrictive bar to one plate of a condenser, the other plate being connected electrically to the grid of the valve whose anode circuit contains the exciting coil of the bar.

THE CRYSTAL CLOCK.—(*Wireless World*, 21st January, 1931, Vol. 28, pp. 69–70.)

*Cf.* 1930 Abstracts, p. 517.

A HIGH PRECISION CHRONOGRAPH.—J. E. Sears and G. A. Tomlinson. (*Journ. Sci. Instr.*, Jan., 1931, Vol. 8, pp. 21–28.)

An accuracy of time measurement of 0.0002 sec. is attained.

SENSITIVE VALVE VOLTMETER.—H. L. Kirke and T. C. Macnamara. (*Wireless World*, 14th January, 1931, Vol. 28, pp. 30–32.)

A simple method of increasing the sensitivity of the slide-back valve voltmeter in the measurement of low voltages. The method consists in the use of a d.c. amplifier after the slide-back valve, with a high resistance in the slide-back anode circuit. The device can be used for measurements at high peak voltage and percentage modulation.

An illustration is given of an actual instrument of this type in use at the Brookmans Park Station of the B.B.C.

DIE MESSUNG DES WECHSELSTROMWIDERSTANDES FLÜSSIGER DIELEKTRIKA (The Measurement of the A.C. Resistance of Liquid Dielectrics). —D. H. Black. (*Zeitschr. f. hochf. Tech.*, Dec., 1930, Vol. 36, pp. 217–219.)

A substitution method, based on Darbord's method for the measurement of dielectric constants. A bridge circuit is used, one arm of which contains a test condenser in parallel with a standard variable condenser. The test condenser at first contains air only, and then is filled with the liquid under investigation. The method is applicable to a large frequency range (600 cycles to 1 megacycle p.s.) and being a substitution method requires no great precautions in screening, etc.

A SIMPLE CAPACITY TEST SET.—W. H. F. Griffiths. (*E.W. & W.E.*, Jan., 1931, Vol. 8, pp. 21–22.)

Description of a portable test set with a range of 0.00005 to 1.0 μF. on a single rotary dial "with no troublesome multiplying devices or range extensions." The enormous range, and the approximately constant openness of scale graduations throughout the range, are due to the fact that the bridge ratio-arms are made continuously variable by ganging two ordinary air condensers in such a way as to make their operation differential. Thus only one value of "known-arm" capacity is necessary to balance a large range of unknown capacities.

A NEW METHOD OF MEASURING THE CAPACITY OF SMALL CONDENSERS.—H. M. Barlow. (*Phil. Mag.*, January, 1931, Ser. 7, Vol. 11, pp. 184–193.)

In applying the Fleming-Clinton method to condensers under about 100 μμF., the inherent capacity of the commutator and accessory apparatus prevents really accurate observations. The writer therefore tried to use a combination of two triodes in place of the commutator, but the scheme was unsatisfactory for reasons which he gives.

The successful arrangement finally adopted was one in which the alternating potential itself was used to charge the condenser periodically in opposite directions, through a pair of ordinary rectifying valves. In some cases it was desirable to flatten the crests of the 800-cycle a.c.—from a valve-controlled tuning fork—so as to give the condenser more time to become fully charged: this was done by using another pair of rectifying valves of a different type which quickly saturate as the applied potential rises.

Using a reflecting galvanometer, scale readings at a metre radius can be obtained of as many centimetres of length as there are centimetres of capacity in the condenser under test. This is true at 800 cycles, and there is no reason why higher frequencies (*e.g.*, from quartz oscillators) should not be used, particularly if the above flat-crested wave-form circuit is employed. For capacities over 50 μμF. a unipivot galvanometer can replace the reflecting type.

Electrical Measuring Instruments Other Than Integrating Metres.—C. V. Drysdale. (*Journ. I.E.E.*, Jan., 1931, Vol. 69, pp. 170–178.)

A review of progress since 1928 in British instruments.

The Measurement of Small Electromotive Forces from Thermopiles.—J. Guild. (*Journ. Sci. Instr.*, Dec., 1930, Vol. 7, pp. 378–385.)

Improved Valve Voltmeters for D.C.—Berl, Wahlig: Wulff, Kordatzky. (*Chem. Fabrik*, Nos. 35–38: 45 and 46.)

The first named authors use the whole potential drop in the filament to reduce the initial current to zero, instead of using a compensating battery. Then if the filament battery voltage falls, the emission decreases but so does the compensating voltage. The last named authors use a compensating battery of such potential as to compensate the drop in a high resistance through which the whole anode current flows; the meter is placed in one of the leads from the compensating battery, which is shunted by a high adjustable resistance.

A Mains-driven Thermionic A.C. Galvanometer for use as Bridge Indicator.—L. Tulauskas. (*Electronics*, Jan., 1931, pp. 478–479.)

Ein empfindliches zweistufiges Röhrenvoltmeter für Netzanschluss (A Sensitive Two-Stage Thermionic Voltmeter for Mains Supply).—K. Schlesinger. (*Zeitschr. f. tech. Phys.*, Feb., 1931, Vol. 12, pp. 114–115.)

Presumably the voltmeter used by von Ardenne in his field-strength measuring equipment (Feb. Abstracts, p. 106). It is independent of frequency between 50 and $10^7$ cycles/sec., and reads from 0.05 to 0.8 v. It is insensitive to small changes in the mains voltage (this being an advantage of the 2-stage over the 1-stage voltmeter), while large changes, up to 40 %, are provided for by the controlling resistance embodied in the set.

The frequency independence is due to the use of d.c. amplification in the second stage. The need for a grid bias battery is avoided by the employment of a bridge circuit with both cathodes insulated. The sensitivity is increased by d.c. retroaction—the grid potential of the first valve is tapped off a resistance which is traversed by the output current of the second stage; this d.c. retroaction leads to no exaggeration of any error due to harmonics.

Ein vereinfachtes Duantenelektrometer und seine Benutzung zu Wechselspannungsmessungen (A Simplified "Duant" Electrometer [with Semi-Circular Fixed Vanes] and its Use in A.C. Measurements).—K. Engel and W. S. Pforte. (*Physik. Zeitschr.*, 15th Jan., 1931, Vol. 32, No. 2, pp. 81–84.)

Über die Grenzen der Empfindlichkeit des Vakuum-Duantenelektrometers (On the Limits of Sensitivity of the Vacuum Duant Electrometer [with Semi-circular Fixed Vanes]).—W. Eggers. (*Ann. der Phys.*, Series 5, 1930, Vol. 7, No. 7, pp. 833–856.)

A Fluxmeter with Counterbalanced Restoring Torque.—F. W. Haworth. (*Review Scient. Instr.*, February, 1931, Vol. 2, pp. 125–128.)

Grassot Electrometer and Its Use in Photoelectric Measurements.—Barthelémy.

(*See* abstract under "Phototelegraphy," par. 3.)

Über die Ausmessung magnetischer Felder mittels Elektronenstrahlen (The Survey of Magnetic Fields by means of Electron Beams).—E. Brüche. (*Zeitschr. f. tech. Phys.*, Feb., 1931, Vol. 12, pp. 94–98.)

Measurement of Ionization Current by Means of the Zeleny Electroscope.—R. Barton. (*Review Scient. Instr.*, February, 1931, Vol. 2, pp. 118–124.)

Rationalisation of the Electromagnetic Equations.—A. Blondel. (*Comptes Rendus*, 9th February, 1931, Vol. 192, pp. 318–320.)

Tuning Coils and Winding Data.—A. L. M. Sowerby. (*Wireless World*, 3rd September, 1930, Vol. 27, pp. 210–213.)

An examination of the principles of r.f. resistance and the effect of coil shape. It is shown how, by simple graphs, it is possible to calculate the correct gauge of wire, covering and number of turns to give the most efficient coil of 1in. to 4in. diameter, whether a plain or ribbed former be used.

A Graphical Calculation of the Inductance of Multi-Layer Coils with any Time Constant.—N. N. Soloviev. (*Westnik Elektrot.*, No. 3, 1930, pp. 98–103.)

In Russian.

Eine zusammenfassende Untersuchung über stehende elektrische Drahtwellen (A Recapitulatory Investigation of Standing Electric Waves on Wires).—R. King. (*Ann. der Phys.*, Series 5, 1930, Vol. 7, No. 7, pp. 805–832.)

An investigation of the Lecher wire system of wavelength determination and production of tuned circuits with linear extensions, its difficulties and the precautions to be taken in its use.

Some Notes on Field-Strength Measurement.—Green. (*See* under "Propagation of Waves.")

## SUBSIDIARY APPARATUS AND MATERIALS.

Some Applications of Condensers with Variable Capacity [Rochelle Salt].—V. P. Vologdin. (*Westnik Elektrot.*, No. 4, 1930, pp. 129–133.)

A description of experiments on Rochelle salt with the object of using condensers of variable capacity, with this salt as dielectric, in current-controlling devices such as ordinarily employ iron-cored chokes. A single crystal of the salt has an enormous dielectric constant (up to 20,000) which varies as a function of the applied e.m.f. and displays a quasi-saturation effect. This function seems to depend little on frequency, up to 100 kc./sec.

The author proposes to apply these properties to radio receiving sets and to H.F.-alternator transmission. *Cf.* Sawyer and Tower, 1930 Abstracts, p. 343.

### A New Type of Variable Condenser (the "Arlt-Nostrator"). (*Rad., B., F. f. Alle*, No. 2, Vol. 10, 1931, pp. 75–76.)

The invention of an Austrian amateur. Both sets of plates are separately rotatable, but about different axes side by side; both have their own particular shape. The one set acts as the stator while the other is moved through 180° to give one complete range (*e.g.*, the short-wave range): then this first rotor, now at its position of maximum entry, becomes the stator, while the former stator is moved through 180° to give a second complete range (*e.g.*, the broadcasting range). The two sets are shaped rather like a fish-hook; in the first rotor the point is sharp, in the second it is rounded: the two axes lie at the inside edge of the bends. The method of adjustment described above is *not* that given in the article, where the movement of the first stator is presumed to be in a few large steps only, the actual tuning being accomplished on the first rotor (with the sharp point). The other method is that given in the advertising leaflet enclosed in the journal.

### On the Electrical Resistance of Contacts between Solid Conductors.—J. Frenkel. (*Phys. Review*, 1st Dec., 1930, Series 2, Vol. 36, No. 11, pp. 1604–1618; 1st Jan., 1931, Series 2, Vol. 37, No. 1, p. 102.)

### Cold Cathode C.-R. Oscillograph of the Russian Electrotechnical Institute.—I. Stekolnikov. (*Westnik Elektrot.*, No. 3, 1930, pp. 43–47.)

Oscillograms, taken direct on silver bromide paper, show that a recording speed of about 1,000 km./sec. is attained.

### An Amplifier, String Galvanometer and Photographic Camera Designed for the Study of Action Currents in Nerve.—A. Forbes, H. Davis and J. H. Emerson. (*Review Scient. Instr.*, January, 1931, Vol. 2 pp. 1–15.)

To replace the cathode-ray oscillograph. The highest speed attained, for satisfactory contrast for reproduction, on a *single* exposure is about 5 metres per sec., though faint but legible records have been made at twice this speed. On the other hand, for *repetitive* phenomena, good records are possible at speeds up to 20 metres per sec.

A quartz string 7 mm. long and $0.6\mu$ in diameter, tightened to a natural period of 10,000 cycles per sec., proved capable of recording these short action currents without appreciable distortion. A six-stage amplifier is used, which is described.

### A Rotary Pump for High Vacua.—Pulsometer Eng. Co. (*Engineer*, 6th Feb., 1931, Vol. 151, p. 168.)

To produce vacua of one-fiftieth mm. mercury in one stage of pumping. Two of these pumps in series will give a vacuum of $7 \times 10^{-5}$ mm. mercury.

### Low Vacuum Pressure Control Apparatus.—L. A. Richards. (*Review Scient. Instr.*, Jan., 1931, Vol. 2, pp. 49–52.)

Applicable to the maintaining of a constant vacuum, down to a few millimetres of mercury, independent of atmospheric changes.

### The Measurement [by a Point-to-Plate Spark Gap] of the Voltage Operating a Self-Rectifying X-Ray Tube.—C. V. Kent. (*Review Scient. Instr.*, Jan., 1931, Vol. 2, pp. 44–46.)

### Transient Currents in Transformers.—H. M. Turner. (*Journ. Franklin Inst.*, Jan., 1931, Vol. 211, No. 1, pp. 1–36.)

A presentation of the fundamental principles underlying the phenomena of transient currents in transformers, when connected to a source of power. "The elements affecting the transient currents are considered individually. The manner in which the current depends upon the initial magnetic state of the core, the magnitude and phase of the impressed e.m.f. at the instant of closing the circuit, and various types of secondary loads are analysed and experimentally verified. A sine wave of impressed e.m.f., $e = E \sin \omega t$, is assumed in all cases."

Use was made of a "transient visualizer," *i.e.*, "a synchronous switch for controlling circuit conditions in connection with oscillographic studies of periodic and transient phenomena." This enabled transient curves to be visually observed on the screen of an oscillograph. It may be used to place a time calibration on a film.

### A Review of High Frequency Attenuation Devices.—R. P. Glover. (*Rad. Engineering*, Nov., 1930, Vol. 10, pp. 23–26 and 36.)

Resistance- and reactance-potentiometers: voltage-drop devices—special attention is here given to the National Physical Laboratory device dealt with by Thomas (1930 Abstracts, p. 464) which is applicable to frequencies up to 60 megacycles per sec., and consists of a thoroughly shielded small impedance in the form of a very short length of fine wire of high specific resistance. The writer refers to the limitation of this and similar devices by the fact that the lower limit of the output voltage is determined by the sensitivity of the current-indicating instrument. He goes on to describe the Hull and Williams design (*Phys. Review*, 1925) of a small known inductance which may be of the order of one ten-thousandth microhenry—a brass rod placed concentrically within a brass tube, the two being well connected at one end which forms one output terminal, while the other terminal is obtained by making connection to the rod at various points by short wires passing through holes in the tube. He suggests that capacity might be a limiting factor at frequencies much above 1½ megacycles per sec.

He then deals with devices depending on mutual inductance, including the "mutual inductor attenuator" described in *Radio Engineering*, June 1930, p. 42 (which is stated to hold its calibration up to about 6 megacycles per sec. and which he considers an important step forward) and the iron-cored current transformers described by Dye (*Journ. I.E.E.*, Vol. 63, p. 579) and studied by the Bureau of Standards (Circ. 74, p. 155). For attenuations of the order of 100,000 to 1, two or more attenuation devices may be cascaded, or different types may be combined—*e.g.*, the current transformer may be combined with the Hull and Williams inductor.

He ends by dealing with special resistance networks, giving as an example the wiring diagram of the General Radio 403-C standard generator embodying such an attenuator; and by pointing out the serious need for improved apparatus for ultra-high frequencies.

PRACTICAL RADIO FREQUENCY CHOKE COILS.—A. Binneweg, Jr. (*Rad. Engineering*, Nov., 1930, Vol. 10, pp. 34–36.)

MARCONI UNDULATOR TYPE U.G.6A.—Marconi Company: J. A. Smale. (*Marconi Review*, Dec., 1930, pp. 17–21.)

For high speed, heavy traffic circuits. No interruption of signals takes place between the finish of one slip and the insertion of another.

SOME PECULIARITIES IN THE THERMO-ELECTRIC PROPERTIES OF MONEL METAL.—E. Meschter. (*Science*, 30th Jan., 1931, Vol. 73, pp. 132–133.)

REPAIR OF NON-CONDUCTIVE GALVANOMETER STRINGS [DEFECTIVE GILDED QUARTZ FIBRES, WITHOUT REMOVAL]. (*Science*, 30th Jan., 1931, Vol. 73, p. 131.)

A MAGNETICALLY OPERATED A.C. VOLTAGE CONTROL DEVICE.—J. G. Sola. (*Rad. Engineering*, Jan., 1931, Vol. 11, pp. 24–25.)

Description, and illustrative curves, of the device referred to in March Abstracts, p. 163.

ELECTROLYTIC CONDENSERS — CHARACTERISTICS AND METHODS OF MEASUREMENT.—W. L. Dunn. (*Rad. Engineering*, Jan., 1931, Vol. 11, pp. 31–33.)

VARIABLE WIDERSTÄNDE UND IHRE HYDRODYNAMISCHE ANALOGIE (Variable Resistances and their Hydrodynamical Analogy).—R. Auerbach. (*Zeitschr. f. Phys.*, Vol. 66, No. 7/8, pp. 499–512.)

A COMPENSATED THERMOPILE FOR MEASUREMENTS OF TOTAL RADIATION.—J. Guild. (*Journ. Sci. Instr.*, Jan., 1931, Vol. 8, pp. 14–17.)

A BALLISTIC HYSTERESIGRAPH.—H. C. Lehde. (*Review Scient. Instr.*, Jan., 1931, Vol. 2, pp. 16–43.)

POWER EQUIPMENT FOR AIRCRAFT RADIO TRANSMITTERS.—J. D. Miner. (*Proc. Inst. Rad. Eng.*, Jan., 1931, Vol. 19, pp. 59–77.)

Types discussed are (i) the wind driven generator, (ii) the dynamotor, (iii) the main engine driven generator, (iv) the auxiliary engine generator set, (v) the combination wind driven generator and dynamotor, and (vi) the constant speed main engine driven alternator. It is concluded that no one type is so superior to the others that its use can be expected to become universal, but the auxiliary engine generator set has the greatest theoretical possibilities.

A SIMPLIFIED METHOD FOR THE CALCULATION OF IRON CONDUCTORS FOR TRANSMISSION LINES.—W. C. Koolebakin. (*Westnik Elektrot.*, No. 4, 1930, Section 2, pp. 49–53) *and* THE CALCULATION OF THE A.C. RESISTANCE OF IRON WIRE.—I. Antik. (*ibid.*, Section 3, pp. 65–68.)

PARAGUTTA, A NEW INSULATING MATERIAL FOR SUBMARINE CABLES.—A. R. Kemp. (*Bell Tech. Journ.*, Jan., 1931, Vol. 10, No. 1, pp. 132–148.)

WOODS FOR INSULATION.—A. R. Dunton and A. W. Muir. (*Electrician*, 13th Feb., 1931, Vol. 106, pp. 237–239.)

Varieties used: methods of impregnation: breakdown voltages of treated woods.

SYNTHETIC RESINS: THEIR USES AS INSULATOR MATERIAL.—E. A. Bevan. (*Electrician*, 13th Feb., 1931, Vol. 106, p. 239.)

Summary of a recent lecture.

INSULATORS TESTED: (5) VITREOSIL AND PYREX.—W. H. Griffiths. (*Wireless World*, 3rd September, 1930, Vol. 27, pp. 227–228.)

Before the introduction of Mycalex, it was necessary to use Vitreosil (pure fused quartz or silica) or Pyrex for insulation if great geometrical permanence of structure was essential in a piece of low-loss wireless apparatus, notably in low-loss air dielectric condensers. Both of these insulators are hard and are, of course, unaffected by heat, since one is a fused silica and the other a glass. Vitreosil has a much lower dielectric loss than Pyrex, but where any degree of strength is required the latter material has to be employed despite its higher power loss, this being yet another case of the stronger material being the more imperfect electrically.

ÜBER VERLUSTE VON KONDENSATOREN BEI SEHR SCHNELLEN ELEKTRISCHEN SCHWINGUNGEN (On Condenser Losses in High Frequency Electrical Oscillations [$10^6$–$10^8$ c.p.s.]).—E. Darmstaedter. (*Arch. f. Elektrot.*, 30th Dec., 1930, Vol. 24, No. 6, pp. 701–714.)

A determination of the differences of loss resistances of rotating plate condensers in air and various fluid dielectrics for frequencies from $2 \times 10^6$ to $10^8$ c.p.s.

Demonstration of an Instrument for Combining Two Curves into One.—J. L. Haughton: R. Payne. (*Proc. Physical Soc.*, 1st Jan., 1931, Vol. 43, Part 1, p. 112.)

Smoothing.—W. T. Cocking. (*Wireless World*, 19th November, 1930, Vol. 27, pp. 564–568.)

A guide to the choice of components for eliminators. Attention is given to the question of progressive smoothing, whereby each stage of a set is considered with regard to the amount of subsequent amplification.

Dry Plate Rectifier using Selenium or Sulphur.—(German Pat. 511038, Mallory, pub. 25th Oct., 1930.)

This patent, of American priority 1925, covers the use of a negative electrode consisting of a combination of an alloy (*e.g.*, brass) with an element of the 6th periodic group, in a ratio of about 1 to 5 or 1 to 6, and a positive electrode made of a light metal of the 2nd or 3rd group.

Researches on the Valve Effect in Aluminium Voltameters.—M. Ginat. (*Assoc. franç. p. l'Av. des Sci.*, 53rd Session, pp. 251–255.)

The Potential of the Walls in the Cathode Dark Space, and the Failure of Discharge Tubes.—Beck and Emeléus: Sloane. (*See* end of abstract under "General Physical Articles.")

## STATIONS, DESIGN AND OPERATION.

Ultra-Short Wave Broadcasting: Latest Progress.—(*Rad.*, *B.*, *F. f. Alle*, No. 2, Vol. 10, 1931, pp. 52–53.)

*Cf.* February Abstracts, p. 89. In the present article it is stated that a 7.05 m. wave is being used in the twice-a-week programme (Tuesdays and Thursdays, 17.30 to 19.30) now being sent out by the Telefunken Company, because it has been found to reach best to the periphery of Berlin and to be completely free from interference *including ignition interference* [contrast February abstract]. A simple audion circuit, which can be attached to the l.f. stages of any Broadcast receiver, is sufficient for reception.

Local Amplification of Field Strength.—E. Schwandt. (*Wireless World*, 3rd December, 1930, Vol. 27, pp. 622–623.)

An article on von Ardenne's first scheme referred to in Jan. Abstracts, p. 52. *See also* Runge, Feb. Abstracts, p. 110.

Multiple Re-Broadcast.—(*Wireless World*, 21st January, 1931, Vol. 28, pp. 55–56.)

Describing von Ardenne's second scheme for long distance reception in cities (*see also* below).

Zur Technik des Sendens und Empfangens von Ultrakurzwellen, die mit mehreren modulierten Hochfrequenzen moduliert sind (On the Technique of Transmission and Reception of Ultra-Short Waves Modulated with Several Modulated High Frequencies).—M. von Ardenne. (*Zeitschr. f. hoch. Tech.*, Jan., 1931, Vol. 37, pp. 12–15.)

Two modulation circuits are described which have shown themselves to be specially suitable for the modulation of an ultra-short wave by one or more radio frequencies (*cf.* March Abstracts p. 165). The importance of effectively screening all parts carrying the medium radio frequencies, to prevent radiation and consequent interference, is explained (later on, the importance of similar screening at the receiver is pointed out). The writer then considers the permissible degree of modulation of the ultra-high frequency by each of the several components. In practice the percentage would be kept below the theoretical maximum value $k = \frac{100}{n + nk_h}$, where $n$ is the number of components and $k_h$ the degree of modulation of each component (giving, for 4 radio frequencies each with 20 % modulation, an ultra-short wave modulation percentage of roughly 20). He then deals with the possible production of interference by overtones and combination tones between the radio frequencies after the demodulation of the ultra-short carrier: "it can be shown, however, *that all combination and over-tones come outside the zone of reception, provided that this is limited to one octave of frequency*." Since, from considerations of power, the number of components is limited, this octave is generally sufficient.

Interference between the several radio frequencies at the transmitter (during the multiple modulation of the ultra-short carrier) is avoided by the introduction of intermediate circuits: sometimes merely the use of loose coupling is sufficient.

A diagram ("Abb. 3," p. 14) is given of a special method of modulating the ultra-short wave with the broadest possible radio-frequency bands—such as those required for television. The paper ends with a discussion of the receiving end. "The special advantage of the multiple [r.f.] modulation system, over a l.f. modulation system, lies in the fact that the selective properties of the broadcast receiver can be utilised for separating the programmes, while the adjustment of the whole equipment remains very simple."

Die grundsätzlichen Schwierigkeiten bei der Feldverstärkung (The Fundamental Difficulties in Field Strengthening [Distant Reception in Cities]).—M. von Ardenne. (*Rad.*, *B.*, *F. f. Alle*, No. 2, Vol. 10, 1931, pp. 72–75.)

A reply to Runge's objections to the writer's first scheme (Runge, February Abstracts, p. 110, and von Ardenne, March Abstracts, p. 165). The questions of selection, quality, and zones of interference ("flicker zones") are dealt with in succession. Judging by his last paragraph, however, the writer places his greatest confidence in his second scheme (multiple r.f. modulation of a single ultra-short wave) dealt with in Jan. Abstracts, p. 52, and above.

Rebroadcasting Distant Transmissions.—G. W. O. H.; von Ardenne. (*E.W. & W.E.*, Feb., 1931, Vol. 8, pp. 59–60.)

Editorial on von Ardenne's proposals (see above).

Wireless Communications.—Chetwode Crawley. (*Wireless World*, 31st December, 1930, Vol. 27, pp. 729–732.)

A record of progress during 1930. The most notable advances are placed to the credit of wireless telephony. Reference is made to the success of the Imperial long-wave telephone services, and the commercial short-wave telephone services to Australia and other countries. The strides made in ship-to-shore telephony are also chronicled.

In regard to radio telegraph services, attention is drawn to the increase in the number of short-wave circuits which came into operation all over the world and to the research undertaken in connection with the bugbear of fading.

THE NEW GERMAN BROADCASTING STATIONS: INTERFERENCE AND FADING TROUBLES OF MÜHLACKER: DESCRIPTION OF THE HEILSBERG STATION, ETC.—(*Rad., B., F. f. Alle*, No. 2, Vol. 10, 1931, pp. 49–52.)

THE DESIGN AND CONSTRUCTION OF BROADCAST STUDIOS.—O. B. Hanson and R. M. Morris. (*Proc. Inst. Rad. Eng.*, Jan., 1931, Vol. 19, pp. 17–34.)

THE ROLE OF RADIO IN GROWTH OF INTERNATIONAL COMMUNICATION.—H. H. Buttner. (*Proc. Inst. Rad. Eng.*, Jan., 1931, Vol. 19, pp. 51–58.)

Including a world map of radiotelephone services in operation, under construction and projected, as in August 1930.

FIELD-STRENGTH CONTOUR MAP OF THE CALCUTTA BROADCASTING STATION.—Rakshit. (*See* abstract under "Propagation of Waves.")

## GENERAL PHYSICAL ARTICLES.

THE POTENTIAL OF THE WALLS IN THE CATHODE DARK SPACE [AND THE DETERMINATION OF TOWNSEND'S IONIZATION COEFFICIENT FOR ELECTRONS].—J. W. Beck and K. G. Emeléus. (*Phil. Mag.*, Jan., 1931, Vol. 11, pp. 54–64.)

Brown and Thomson's method of finding the potentials in the dark space (1930 Abstracts, p. 353) led to values for the ionization coefficients which differed from Townsend's: it was thought that this might be due in part to the effect of wall charges in their discharge tubes, and the present tests were made partly to examine this possibility. For cathode falls not greater than 440 v. the walls are strongly positive to the discharge close to the cathode and negative in the negative glow, so that walls and discharge are at the same potential in one place, which proves to be at the boundary of the negative glow and cathode dark space. The bearing of the results on those of Brown and Thomson's is discussed, and the difficulty of obtaining a theory of the wall potential is pointed out. The bearing of the present results on the failure of discharge tubes is discussed by Sloane in *Phil. Mag.*, Dec., 1930, p. 1099.

RECHERCHES SUR L'EFFET VOLTA (Researches on the Volta Effect).—E. Dubois. (*Ann. de Physique*, Dec., 1930, Vol. 14, pp. 627–725.)

Volta effect measurements made on the cold metal after it has been heated *in vacuo* lead the writer to conclude that (i) the metal first shows (for moderate heating) a variation of Volta effect in the + *ve* direction (due to removal of oxygen); (ii) for heating to higher temperatures, a − *ve* variation is then found (due to removal of water vapour); and (iii) for every heating there occurs a + *ve* variation with time, for which various explanations are suggested; the one favoured as being simplest is that this variation with time is an intrinsic property of the metal, the electronic emission in the cold state being more feeble when the metal has just been the seat of considerable emission due to the heating.

CONTACT POTENTIAL BETWEEN IRON AND NICKEL.—G. N. Glasoe. (*Phys. Review*, 1st Jan., 1931, Series 2, Vol. 37, No. 1, p. 102.)

Abstract only. The contact potential $Fe-Ni$ is found to be + 0.20 volt.

UNTERSUCHUNGEN ÜBER KONTAKTPOTENTIALE. I. VERSUCH EINER MESSUNG DER KONTAKTPOTENTIALE ZWISCHEN METALLEN UND ISOLATOREN (Investigations on Contact Potentials. I. Experimental Measurement of the Contact Potentials between Metals and Insulators).—F. Polednik. (*Zeitschr. f. Phys.*, Vol. 66, No. 9/10, pp. 619–631.)

UNTERSUCHUNGEN ÜBER KONTAKTPOTENTIALE. II. EIN VERSUCH ZUR BESTIMMUNG DER POTENTIALDIFFERENZEN ZWISCHEN SALZEN UND IHREN GESÄTTIGTEN LÖSUNGEN (Investigations on Contact Potentials. II. Experimental Determination of the Potential Differences between Salts and their Saturated Solutions).—Marianne Lederer. (*Zeitschr. f. Phys.*, Vol. 66, No. 9/10, pp. 632–645.)

THE PRODUCTION OF HIGH SPEED CANAL RAYS WITHOUT THE USE OF HIGH VOLTAGES.—E. O. Lawrence and D. H. Sloan. (*Proc. Nat. Acad. Sci.*, Jan., 1931, Vol. 17, pp. 64–70.)

Development of the "accelerating" principle of Wideroe (1929 Abstracts, p. 169). Results already obtained indicate that the technique is capable of yielding 2,500,000-volt singly charged mercury ions.

SUR LA CAPTURE D'ÉLECTRONS PAR DES IONS POSITIFS (The Capture of Electrons by Postive Ions). J. L. Destouches. (*Comptes Rendus*, 9th February, 1931, Vol. 192, pp. 345–348.)

IRROTATIONAL MOTION OF A COMPRESSIBLE INVISCID FLUID.—H. Bateman. (*Proc. Nat. Ac. Sci.*, Dec., 1930, Vol. 16, pp. 816–825.)

ON THE INTENSITY OF TOTAL SCATTERING OF X-RAYS BY MONATOMIC GASES.—Y. H. Woo. (*Proc. Nat. Ac. Sci.*, Dec., 1930, Vol. 16, pp. 814–816.)

RELATIONS SIMPLES DU SPECTRE MOLÉCULAIRE AVEC LA STRUCTURE DE LA MOLÉCULE (Simple Relations between Molecular Spectrum and Molecular Structure).—H. Deslandres. (*Comptes Rendus*, 29th Dec., 1930, Vol. 191, pp. 1404–1407.)

Théorèmes relatifs à la Brillance des Sources secondaires (Theorems relating to the Brilliance of Secondary Sources).—J. Dourgnon and P. Waguet. (*Comptes Rendus*, 22nd Dec., 1930, Vol. 191, pp. 1314–1316.)

Sur le Calcul graphique des Grandeurs attachées a l'Électron en Mouvement (The Graphical Calculation of the Magnitudes associated with the Electron in Motion).—G. Fournier. (*Comptes Rendus*, 22nd Dec., 1930, Vol. 191, pp. 1302–1304.)

Optische Untersuchung der Funkenzündung in Luft von Atmosphärendruck mittels des Kerreffektes (Optical Investigation of Sparking Breakdown in Air at Atmospheric Pressure using the Kerr Effect).—L. v. Hàmos. (*Ann. der Phys.*, Series 5, 1930, Vol. 7, No. 7, pp. 857–888.)

Luftdurchschlag und Überschlag mit Wechselspannung von 50 und 100,000 Hertz (Breakdown and Flash-over in Air with Alternating Voltage at 50 and 100,000 c.p.s.).—J. Kampschulte. (*Arch. f. Elektrot.*, 7th Nov., 1930, Vol. 24, No. 4, pp. 525–552.)

Durchschlagspannung und Bestrahlung (Breakdown Voltage and Irradiation).—K. Masch. (*Arch. f. Elektrot.*, 7th Nov., 1930, Vol. 24, No. 4, pp. 561–562.)

Calcolo statistico dello Spettro di un Atomo ionizzato (Calculation, by Fermi Statistics, of the Spectrum of an Ionised Atom).—E. Segrè. (*Nuovo Cim.*, No. 8, Vol. 7, 1930, pp. 326–329.)

Die spezifische Ladung des Elektrons (The Specific Charge on the Electron).—F. Kirchner. (*Physik. Zeitschr.*, 15th Dec., 1930, Vol. 31, No. 24, pp. 1073–1075.)

Improved measurements with the help of a piezo-quartz oscillator lead to the value

$$10^{-7} \, . \, \frac{e}{m_0} = 1.7602 \pm 0.0025 \text{ e.m.u.}$$

for the ratio of the specific charge on the electron to its mass.

On the Rotation of Dielectrics in Electrostatic Fields and Related Phenomena.—L. G. Vedy. (*Proc. Cam. Phil. Soc.*, Jan., 1931, Vol. 27, Part 1, pp. 91–102.)

Sur la Mécanique ondulatoire des Champs d'Ondes (The Wave Mechanics of Wave Fields).—Gr. C. Moisil. (*Comptes Rendus*, 19th Jan., 1931, Vol. 192, pp. 149–151.)

Sulla Relazione $E = h\nu$ nella Meccanica ondulatoria (On the Relation $E = h\nu$ in Wave Mechanics).—E. Persico. (*Nuovo Cim.*, No. 9, Vol. 7, 1930, pp. 344–347: *Atti Accad. Lincei*, Vol. 11, 1930, pp. 985–988.)

The writer shows that to arrive at the Schrödinger equation it is not necessary to postulate the relation $E = h\nu$, but that this can be demonstrated within quite wide conditions: if the frequency of the de Broglie waves stands in any relation whatever with the energy, it can be proved that this relation must be $E = h\nu + b$, where $b$ is the ordinary additive constant of the energy, arbitrary with non-relativistic considerations but fixed with relativistic.

L'Introduction de l'Échange dans la Statistique d'un Gaz d'Électrons (The Introduction of Exchange in the Statistics of an Electron Gas).—L. Goldstein. (*Comptes Rendus*, 22nd Dec., 1930, Vol. 191, pp. 1306–1308.)

Undulatory Geometry and its Dynamic Considerations.—A. Buhl. (*Comptes Rendus*, 29th Dec., 1930, Vol. 191, pp. 1429–1431.)

Sopra un Esempio di Trattazione quantistica di un Fenomeno di Interferenza (An Example of the Quantistic Treatment of an Interference Phenomenon).—G. Racah. (*Nuovo Cim.*, No. 8, Vol. 7, 1930, pp. 330–336.)

## MISCELLANEOUS.

On the Operational Solution of Linear Finite Difference Equations [Theory Applicable to Wave Filter Chains].—L. M. Milne-Thomson. (*Proc. Camb. Phil. Soc.*, Jan., 1931, Vol. 27, Part 1, pp. 26–36.)

The Application of Least Squares.—W. E. Deming. (*Phil. Mag.*, Jan., 1931, Series 7, Vol. 11, No. 68, pp. 146–158.)

"The principle of least squares is applied to the general problem of finding the most probable values of observed quantities and of parameters that are related by equations of various sorts. . . . The application to curve fitting is discussed in detail."

On Heaviside's Operational Solution of a Volterra's Integral Equation when its Nucleus is a Function of $(x - \xi)$ [Application to Electric Circuit Theory].—S. Koizumi. (*Phil. Mag.*, Feb., 1931, Series 7, Vol. 11, No. 69, pp. 432–441.)

Über ein Verfahren zur graphischen Behandlung elektrischen Schwingungsvorgänge (On a Method for the Graphical Treatment of Electrical Oscillatory Phenomena).—F. Kirschstein. (*Arch. f. Elektrot.*, 30th Dec., 1930, Vol. 24, No. 6, pp. 731–762.)

The Application of Functional Operations to a Class of Integral Equations occurring in Physics. [Application to Electric Circuit Theory].—H. P. Thielman. (*Phil. Mag.*, Supp. No., Feb., 1931, Series 7, Vol. 11, No. 70, pp. 523–535.)

On Simultaneous Operational Calculus [Application to Electric Circuit Theory].—B. van der Pol and K. F. Niessen. (*Phil. Mag.*, Feb., 1931, Series 7, Vol. 11, No. 69, pp. 368–376.)

Impulse Functions [Application to Theory of Transients].—W. E. Sumpner. (*Phil. Mag.*, Feb., 1931, Series 7, Vol. 11, No. 69, pp. 345–368.)

Ein allgemeines Integrationsverfahren für quasiharmonische Schwingungsvorgänge (A General Integration Method for Quasi-Harmonic Oscillation Processes).—E. Schwerin. (*Zeitschr. f. tech. Phys.*, Feb., 1931, Vol. 12, pp. 104–111.)

The writer first develops an analytical solution (based on cylindric functions of the first and second kind) of an oscillatory process in which the elasticity, as well as the exciting force, varies linearly with time. He then extends his treatment to quasi-harmonic oscillations of any kind, by replacing the curves elasticity/time and force/time by polygons as nearly coincident as possible, and applying the method to the sides of these.

Vektordarstellung von Interferenzerscheinungen (The Vectorial Representation of Interference Phenomena).—W. Späth. (*Zeitschr. f. tech. Phys.*, Feb., 1931, Vol. 12, pp. 121–122.)

"Interference phenomena can be represented clearly by vector diagrams. The phase variation passed through by the resultant vector during one beat is a fundamental magnitude, whose measurement is demonstrated by an example in connection with a twin-screw turbine ship."

The Concentrating of X-Rays.—M. Pierucci. (*Nuovo Cim.*, Vol. 7, 1930, pp. 245–247.)

A beam containing rays of different frequencies, and concentrated in a space of a few mm. in width and depth, is obtained by reflection in short mica cylinders of various diameters.

Schwächung von Strahlen verschiedener Wellenlänge durch Tau-Schichten (The Weakening of Rays of Various Wave Lengths by Layers of Dew).—C. Müller, R. Frisch and W. Scheib: Bäseler. (*Zeitschr. V.D.I.*, 22nd Nov., 1930, Vol. 74, No. 47, pp. 1625–1626.)

In connection with his optical train control system, Bäseler found that while his apparatus, using visible light, was untroubled by fog, certain fairly rare conditions of thick smoke and of dew gave trouble by their effects on the track mirrors. The present experiments were carried out by the Reichsanstalt to see whether the longer infra-red rays would be absorbed and dispersed to a smaller degree, as might be expected from Rayleigh's law. It was found that under the conditions of the test, in which dew was formed artificially on the mirror surface, rays of $1\mu$ wavelength were weakened two or three times as little as those of $0.63\mu$.

The Detection of Rock Salt by the Methods of Electrical Surveying.—T. Alty and S. Alty. (*Canadian Journ. of Res.*, Dec., 1930, Vol. 3, pp. 521–525.)

Properties of Dielectrics in Electric Fields. —A. M. Thomas. (*Nature*, 3rd Jan., 1931, Vol. 127, pp. 14–15.)

A letter advocating the use of the term "permittivity" (originally proposed by O. Heaviside) in place of "specific inductive capacity" or "dielectric constant."

Über ein optisches Verfahren zur Fourieranalyse (On an Optical Method of Fourier Analysis).—B. Germansky. (*Ann. der Physik.*, 1930, Series 5, Vol. 7, No. 4, pp. 453–469.)

The principle of the method is as follows:—a parallel beam of light falls at grazing incidence on a plane reflecting surface. The function to be investigated is suitably traced on this surface by partially covering it with a non-reflecting substance. Measurement of the resulting diffraction effects gives the desired Fourier analysis.

The theory of the method and full practical details for its application are given. Its advantages are (1) rapidity; for all subsidiary frequencies are determined at once; (2) that curves may be investigated whose subsidiary frequencies are not moderately large multiples of a fundamental frequency. It should be particularly useful for the investigation of seismic or meteorological curves.

Über ein Phänomen des Auftretens von Äquipotentiallinien im elektrischen Feld (A Phenomenon of the Appearance of Equipotential Lines in an Electric Field).—P. Böning. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 12, 1931, pp. 50–53.)

Description and interpretation along the lines of space charge and the effect of adsorbed ions, of new results obtained with glass plates dusted over with carbon particles.

The Body as Antenna.— –. Raab. (*Rad., B., F. f. Alle*, Dec., 1930.)

An effect noticed on putting a finger on the aerial terminal of a small receiver is described: reception was good and interference (*e.g.*, from ultra-violet ray apparatus) was greatly reduced in proportion.

Industrial Uses of Electron Tubes.—W. R. G. Baker, A. S. Fitzgerald, and C. F. Whitney. (*Electronics*, Jan., 1931, pp. 467–469.)

Phase-relation control; power control by Thyratron governed by high vacuum triode (Pliotron); Thyratron as a tuned relay (*e.g.* for remote control of circuits by carrier current); Thyratron flasher, etc. Other circuits and uses will be given in a later article.

High Lights on Electronic Devices in Industry. —(*Electronics*, Oct., 1930, pp. 338–339.)

Inspecting high-speed machines with the "Stroboglow": preparation of printing plates or engravings direct from the copy itself: "breath" relays for extending operator's control (*e.g.* for aircraft or motor cars): etc.

THE AUSCULTATION OF WATCHES WITH THE AID OF VALVE AMPLIFIERS.—G. P. Arcay and A. Tissot. (*Assoc. franç. p. l'Av. des Sci.*, 53rd Session, pp. 234–238.)

One of three papers on modern research in chronometry.

COLOUR DEFINITION BY PHOTOELECTRIC MEASUREMENTS.—H. Ellsworth and P. McMichael. (*Electronics*, Oct., 1930, pp. 320–322 and 360.)

THE RADIO KNIFE [ELECTRO-SURGERY].—C. R. Underhill. (*Electronics*, Oct., 1930, pp. 317–319 and 362.)

A paper on bloodless surgery with the high-frequency scalpel (*cf.* Bauer, 1930 Abstracts, p. 587). Of importance is the list given of recent papers on " radio surgery " appearing in the medical press.

THE PHOTO CELL AS APPLIED TO INDUSTRIAL PROBLEMS.—J. V. Breisky. (*Electronics*, Aug., 1930, pp. 227–229 and 266.)

TELEFONIA OTTICA CON RADIAZIONI INVISIBILI (Optical Telephony with Invisible Radiations).—A. Majorana. (*Nuovo Cim.*, No. 8, Vol. 7, 1930, pp. CXC–CCI.)

STÖRSCHUTZ " RADIOPUR " FÜR DEN RUNDFUNK (" Radiopur " Interference Suppressor in connection with Broadcast Reception).—H. Baumeister. (*AEG-Mitt.*, November, 1930, p. 718.)

The AEG are now incorporating a condenser, inductance, or a combination of both, in their motors, etc. ; *e.g.*, inside the casing of a fan-motor. This plan does away with the bad effect of leads to a separate unit and is far cheaper than the latter. Apparatus thus equipped is sold at a very slightly increased price, under the special type title " Radiopur."

INTERFERENCE WITH BROADCAST RECEPTION.—(*Journ. Télégraphique*, Berne, Aug. and Sept., 1930, pp. 207–210 and 235–242.)

The second part discusses the administrative and legislative measures now being adopted in certain countries to render obligatory the steps discussed in the first part, to prevent the production of interference by electrical machinery, etc.

[PRACTICAL TECHNIQUE OF] CATHODE SPUTTERING.—C. H. Cartwright. (*Review Scient. Instr.*, Dec., 1930, Vol. 1, pp. 758–763.)

PHOTOELECTRIC MASTER VOLTAGE CONTROL, USED IN VALVE TEST ROOMS.—W. P. Koechel. (*Electronics*, Dec., 1930, pp. 418–419.)

A photoelectric monitoring meter is connected by a commutator once every 80 seconds to the 17 different voltage circuits in constant use. A voltage 1 % above or below normal gives an immediate alarm.

AUTOMATIC TELEPHONE CALLS RENDERED AS VOICE CALLS.—(*Electronics*, Dec., 1930, p. 424.)

A Bell Laboratories arrangement for use during the transition from manual to dial operation. When the subscriber dials a number, the latter is recorded on relays in the sending mechanism and remains stored until the operator is free to complete the call. On pressing a button the stored number is repeated vocally by means of a number of short strips of sound film, each mounted on a separate drum.

INFLUENCE DES OSCILLATIONS À HAUTE FRÉQUENCE SUR LES TRAITEMENTS DES PRODUITS MÉTALLURGIQUES (The Influence of High Frequency Vibrations on the Treatment of Metallurgic Products).—G. Mahoux. (*Comptes Rendus*, 22nd Dec., 1930, Vol. 191, pp. 1328–1330.)

Remarkable results in improving the characteristics (Vickers-Brinell hardness, magnetic susceptibility, etc.) of steel and certain alloys, used in aeronautical construction, have been obtained by the writer with the aid of high frequency vibrations [frequency not mentioned]. The samples of metal are either introduced into the circuit of an " electromagnetic oscillator " or are mechanically connected to a plate of steel in which the h.f. vibrations are set up by means of an inductance coil excited by an oscillating circuit. In most cases (but not all) a stream of carburating or nitrogenating gas is passed over the metal during the treatment, which lasts 9-10 hours. Further researches are being carried out at the works of the Soc. Lorraine-Diétrich and elsewhere.

ELECTRONIC RECORDING OF HIGH-SPEED PROJECTILES.—(*Electronics*, Dec., 1930, p. 419.)

THERMIONIC VALVES IN A VISCOSITY METER.—(U.S. Pat. 1780952, Symmes : Hercules Powder Co.)

TALKING ALONG A BEAM OF LIGHT.—M. Leeuwin. (*Wireless World*, 17th September, 1930, Vol. 27, pp. 290–292.)

Practical instructions for establishing two-way communication through the agency of a beam created by a " modulated " flash lamp bulb. The receiver consists of a well-screened photo-electric cell coupled by means of a very high resistance to a three-stage transformer-coupled amplifier.

NAISSANCE ET DÉVELOPPEMENTS DE LA RADIOÉLECTRICITÉ (The Birth and Developments of Radio-Electricity).—A. Blondel. (*Génie Civil*, Jubilee Number, Nov., 1930, pp. 127–134.)

# Some Recent Patents.

*The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.*

## AERIAL SYSTEMS.

*Application date, 5th July,* 1929. *No.* 336223.

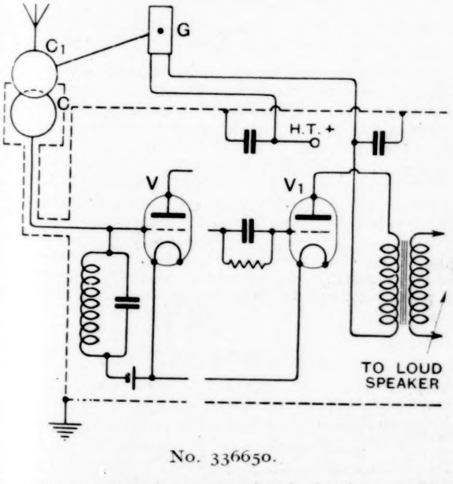
A short-wave aerial comprises a number of horizontal conductors, connected in series by vertical feeders forming a Lecher system. A standing wave is set up having loops at the centre of each horizontal conductor or radiator. The aerial is tuned by adjusting the point at which the power supply is coupled to the Lecher feed-wires. Radiation is directional in the horizontal plane, but non-directional vertically, so that changes in the height of the Heaviside layer do not affect reception.

Patent issued to M. A. Bontch-Brouewitch and V. V. Tatarinov.

## ANTI-FADING CONTROL.

*Application date, 15th July,* 1929. *No.* 336650.

In order to compensate for signal fluctuations due to fading, a small variable condenser *C*, $C_1$ in the aerial circuit is automatically adjusted by means of a moving-coil galvanometer *G* in the output circuit of the detector valve $V_1$, so that as the carrier-wave input increases, the corresponding change in the rectified output diminishes the effective input to the first HF stage *V*. Conversely, a falling-off in the strength of the carrier wave produces an increase in the aerial coupling so as to maintain a constant level of volume in the loud speaker. The control condenser *C*, $C_1$ is so small that it does not affect the overall aerial tuning. As the relative strength of modulation remains unaltered, no distortion is introduced.



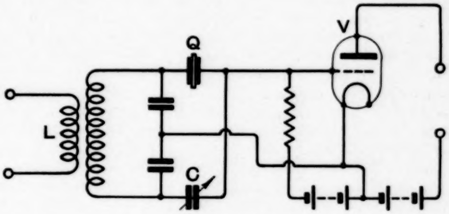
No. 336650.

Patent issued to F. S. Barton.

## PIEZO-ELECTRIC CIRCUITS.

*Application date, 26th July,* 1929. *No.* 337049.

Relates to a method of balancing a piezo-electric crystal when used as a narrow filter circuit in a highly-selective receiving circuit, such as that known as the Stenode Radiostat. Intermediate-frequency signals flowing in a coil *L* are applied through the crystal *Q* to a detector valve *V* in such a way that the static capacity effect of the crystal and its holder is neutralised by a variable condenser *C*, which forms one arm of a balanced Wheatstone bridge. After the condenser *C* has been initially set to balance the undesired capacity effect of the crystal, it may be readjusted to reduce the effect of any interfering signal passing through the crystal.



No. 337049.

Patent issued to J. Robinson.

*Application date, 26th July,* 1929. *No.* 337050.

Two tuned circuits are used in parallel as an input or intervalve coupling. To sharpen the resonance curve to the well-known "crevasse," one circuit is shunted by a piezo-electric crystal, both circuits and the crystal being tuned to the same frequency. The two circuits are fed in parallel so far as the input is concerned, but the output coil of the second tuned circuit is reversed, relatively to that of the first, so as to balance out any transfer of energy except that due to the crystal alone.

Patent issued to J. Robinson.

## MOVING COIL SPEAKERS.

*Application date, 30th September,* 1929.
*No.* 336084.

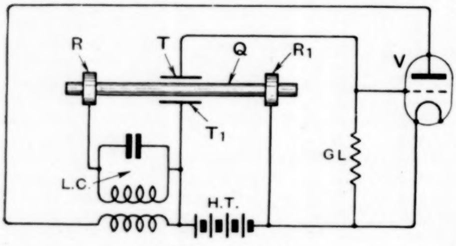
The usual centering-device, for preventing lateral movement, is formed in one piece with the support upon which the moving-coil is wound, so that there is only one joint at the smaller end of the diaphragm, instead of two. This simplifies construction and minimises danger of "rattle" between the jointed parts.

Patent issued to General Electric Co., Ltd., F. Clark and N. J. McAinsh.

## GENERATING OSCILLATIONS.

*Convention date (Germany), 2nd November,* 1928.
No. 334765.

A defect of the mechanical oscillators used in radio practice, such as piezo-electric or magnetostrictive substances, is that the normal frequency of vibration is affected by temperature changes. The present invention consists in using dielectric or conductive substances, having a very small temperature coefficient, for producing sustained high-frequency vibrations in combination with a back-coupled valve. As shown, a rod $Q$ of fused quartz (which has no piezo-electric action) is mounted in two end rings $R$, $R_1$, in circuit across the HT battery. Two central electrodes $T$, $T_1$ form a condenser, of which the quartz $Q$ is the dielectric, and which is in series with a grid resistance $GL$ across the battery HT. Oscillations in the circuit $LC$ produce an alternating voltage between the rings $R$, $R_1$, which in combination with the direct voltage from the battery HT cause the rod to be alternately expanded and contracted longitudinally by the electric field through the dielectric. This varies the effective capacity of the condensers $T$, $T_1$, so that a fluctuating voltage is produced across the resistance $GL$, which is in phase, and synchronous with the mechanical vibration of the rod $Q$, so that the vibration is maintained by the valve $V$. A similar arrangement is described in which a conducting substance acts as a mechanical vibrator and back-coupling element.



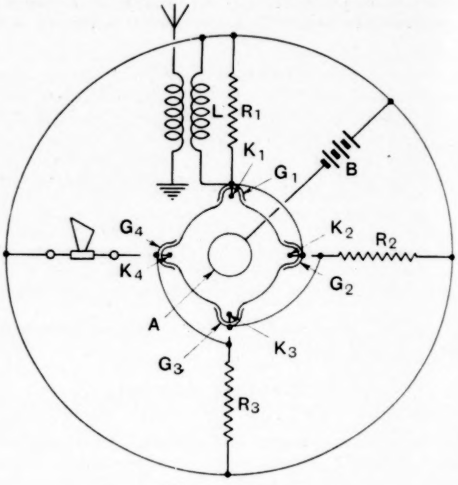
No. 334765.

Patent issued to Telefunken Gesell. für Drahtlose Telegraphie m.b.H.

## EXTERNAL-GRID VALVES.

*Convention date (Germany), 25th June,* 1928.
*No.* 314332.

The control grid is mounted on the outside surface of a flattened glass bulb, the filament and plate being mounted parallel to the long axis of the bulb, so that the discharge stream flows across that axis. Various constructions of valve are described, of which that shown in the Figure is of the multistage type. A common anode $A$ is fed from battery $B$, the negative pole of which is connected through resistances $R_1$, $R_2$, $R_3$ to the various cathodes $K_1$, $K_2$, $K_3$, and through a loudspeaker $LS$ to the cathode $K_4$. The input from the aerial is fed through a coil $L$ connected between the external grid $G_1$ and cathode $K_1$ of the first stage, the other three stages being resistance-coupled in cascade. The cathode is always located nearer to the wall of the bulb, *i.e.* to the external grid, than to the anode.



No. 314332.

Patent issued to Telefunken Gesell. für Drahtlose Telegraphie m.b.H.

## BEAM SIGNALLING.

*Convention date (Poland), 5th March,* 1929,
*No.* 334977.

In order to reduce the lateral spacing of the aerial "arrays" used for short-wave directional signalling, the distance between adjacent aerial wires is reduced say from one-half to one-sixteenth of a wavelength, and the directional effect is recovered by stepping-up the frequency of the received signals to a corresponding degree, *i.e.*, if the normal spacing is reduced to one-eighth the frequency is multiplied by eight. Supersonic heterodyning is used, and by separately adjusting the phases of the different heterodynes the direction of the resulting beam can be rotated as desired.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

## TELEVISION SYSTEMS.

*Application date, 24th May,* 1929. *No.* 333942.

In transmission a certain portion of the picture or scene, comprising the focus of interest, is given an enhanced brilliance over the general background. To attain this object, in addition to the usual series of light sensitive cells arranged above and below the picture, there is provided a central cell fed by a lens focused on the particular area to be emphasised. The output from this extra cell is added to the modulation currents from the other cells.

Patent issued to J. L. Baird and Television, Ltd.

## AUXILIARY TUNING-INDICATORS.

*Convention date (U.S.A.), 17th May, 1928.*
*No.* 311821.

When automatic gain control is applied by means of an auxiliary biasing-valve to maintain a constant volume of signal in the headphones, an operator is to a considerable extent deprived of the audible indication which he would otherwise have to guide him in making tuning adjustments. To provide a visible indication, the plate circuit of the second detector (in a supersonic receiver) includes a milliammeter the current through which varies with the signal intensity. Minimum current in the ammeter indicates that the circuits are in resonance with the incoming carrier wave. Once tuning has been effected, deflections in the meter indicate the extent and duration of subsequent periods of fading.

Patent issued to British Thomson-Houston Co., Ltd.

## STABILISING DIRECT-COUPLED AMPLIFIERS.

*Convention date (U.S.A.), 17th October, 1928.*
*No.* 335068.

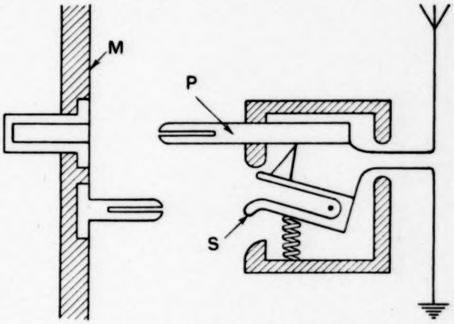
In cascade amplifiers of the type in which the plate of one valve is directly connected through a resistance to the grid of the next, there is a tendency to instability due to the effect of temperature changes on the coupling-resistances. In the arrangement shown, this tendency to drift out of the correct frequency-range is automatically corrected by means of a relay *R*, which is inserted in the plate circuit of the last push-pull amplifier stage *V*, and operates to control the effective intensity of the light-ray from a lamp *L* falling upon a photo-sensitive cell *C* in the input of the first valve. As shown in the detail figure, a shutter *S* is moved by the relay across an opening *O* in a screen between the lamp *L* and the sensitive cell. A decreasing current in the output stage opens the shutter so that more light passes through on to the cell *C*, and *vice-versa*.

Patent issued to British Thomson-Houston Co., Ltd.

## AERIAL EARTHING SWITCHES.

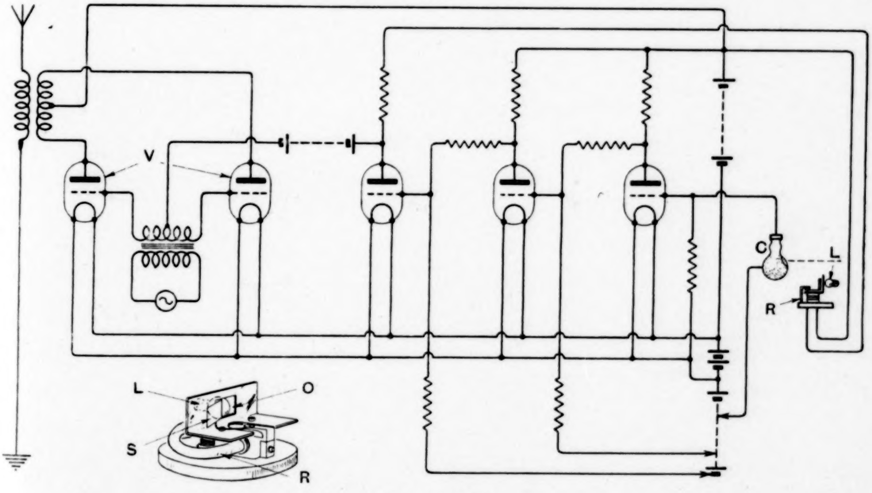
*Application date, 22nd August, 1929. No.* 335342.

The aerial and earth leads are respectively connected to plug and socket members *P*, *S*, the latter of which is spring-biased to make contact with the former, so that when the set is not in use the aerial is directly earthed. Connection between the aerial and receiver is effected by plugging-in a separate member *M*, the terminals of which are connected across the input circuit of the set.



No. 335342.

Patent issued to the Gramophone Co., Ltd. and A. Whitaker.



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### RECTIFYING SETS.

*Convention date (Holland) 24th October, 1928, No.* 336047.

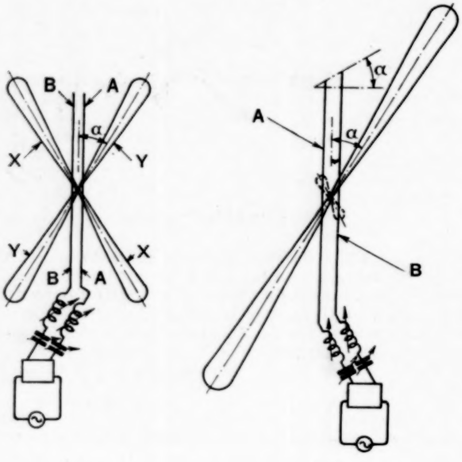
In order to suppress parasitic high-frequency oscillations set up in the circuits of a full-wave thermionic rectifier, a condenser is inserted between each of the two anodes and the common filament. Both shunt condensers are housed either in the cap of the valve or inside the bulb.

Patent issued to N. V. Philips' Gloeilampenfabrieken.

### DIRECTIONAL AERIALS.

*Convention date (U.S.A.) 7th September, 1928. No.* 318619.

If a pair of " free end " conductors, *A*, *B*, several wavelengths long, are energised in phase opposition so that separate standing-wave systems are set up, the resultant radiation consists of conjugate lobes *X*, *Y*, lying at an angle $\alpha$ to and in the plane of the conductors. Radiation normal to the plane of the conductors is prevented by the spacing between *A* and *B* and consequent mutual interferences between the standing-wave elements. By staggering the ends of the pair of conductors by an angle $\alpha$ as shown in Fig. (b), the two lobes are reduced to one. The system is finally made unidirectional by arranging a second similar pair of staggered conductors an odd number of quarter wavelengths away from, and energised in quadrature with the first pair, so as to cut off the rear lobe of radiation.



(a) (b)

No. 318619.

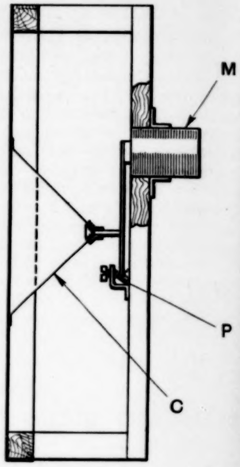
Patent issued to Marconi's Wireless Telegraph Co., Ltd.

### LOUD SPEAKERS.

*Application date, 23rd July, 1929. No.* 336322.

The moving-coil system *M* drives a light cone *C* through a reducing lever pivoted at *P*, the diaphragm consisting of a stretched linen sheet to which the flat base of the cone is secured. The arrangement allows the speaker to be adjusted to favour different bands of frequency by varying (*a*) the ratio of moving-coil movement to diaphragm movement, (*b*) the size of the diaphragm, (*c*) the size and angle of the cone.

Patent issued to A. W. Harris.

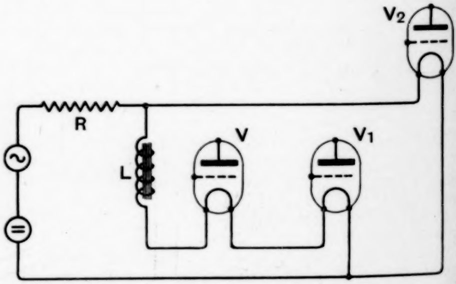


No. 336322.

### DIRECTLY-HEATED VALVES.

*Convention date (Germany), 8th November, 1928. No.* 336128.

In order to reduce the effect of residual fluctuations from a rectified a.c. or pulsating d.c. supply, the total heating-current is passed through a single series resistance *R*, whilst a smoothing-choke *L* is inserted only in the branch feeding those valves *V*, $V_1$ taking the smaller amount of current, *i.e.*, the first stages of amplification and detection. The power stage $V_2$ is, of course, comparatively insensitive to a.c. fluctuations. The arrangement also prevents saturation of the core of the choke *L* by a heavy d.c. component, and allows the usual shunt or smoothing condenser to be dispensed with.



No. 336128.

Patent issued to Telefunken Gesell. für Drahtlose Telegraphie m.b.H.